Urban Forest Resource Analysis
Pacific Grove, California
2015

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company

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Pacific Grove, California

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Executive Summary

Community trees play a critical role in the City of Pacific Grove, California. They provide numerous benefits both tangible and intangible to residents, visitors, and neighboring communities. With a publicly-owned urban forest of 8,017 individual sites, including 7,394 trees and 623 vacant sites, the City's Forestry Department recognizes that community trees are a valued resource, an important component of the urban infrastructure, and part of the City's identity.

In 2015, to support the preservation and management of community trees, the City commissioned an inventory of public trees within the city right-of-way (ROW) on streets and in parks (only trees greater than 6 inches in diameter and within 50 feet of the street were collected). The inventory produced a GIS layer that includes vital information about each tree including species, size, condition, and geographic location. Davey Resource Group (DRG) used this data in conjunction with i-Tree *Streets* benefit-cost modeling software to develop a detailed and quantified analysis of the current structure, function, and value of the community urban forest. This report details the results of that analysis.

Pacific Grove's community urban forest provides nearly $2.3 million in annual benefits ($80 per capita). These benefits include air quality improvements, energy savings, stormwater runoff reduction, atmospheric CO_2 reduction, and aesthetic contributions to the social and economic health of the community. The annual investment (cost) to maintain the 7,394 public trees is approximately $299,571. **For every $1 invested in the community urban forest, Pacific Grove receives $4.11 in benefits.**

The community urban forest is reducing annual electric energy consumption by 996 MWh and annual natural gas consumption by 20,329 therms, for a combined value of $176,195. Tree canopy from public trees reduces annual stormwater runoff by more than 14.2 million gallons and protects local water resources by reducing sediment and pollution loading. To date, public trees have sequestered 15,442 tons of carbon (CO_2). They continue to sequester an additional 910 tons of CO_2 each year for an annual net benefit valued at $17,704. Each year public trees are removing 1.9 tons of pollutants from the air, including ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulates (PM_{10}). Biogenic organic compounds (BVOCs) that are produced by the trees offsets annual air quality benefits by -$66,401. However, the overall environmental benefits from this resource more than compensates for the annual air quality deficit.

The community urban forest in Pacific Grove is well established and in overall fair to good condition. The resource has a predominance of established young trees, with nearly 30% of trees 6"-12" diameter at breast height (DBH). With proper management, and planning, the environmental and economic benefits from this resource will continue to increase over time. Regular inspection and proactive maintenance will ensure the preservation of existing benefits, support individual tree longevity, and help manage risk.

Trees are a part of the City's infrastructure and character. Unlike most other public assets, with proper maintenance, trees have the potential to increase in value over time. With an established population in fair to good condition, a high percentage of young trees, and more than 136 different species, the community urban forest in Pacific Grove will continue to be a vital asset to the City and neighboring communities.

Introduction

Pacific Grove is a coastal city located 45 miles south of Santa Cruz. It shares boarders with the Monterey Bay, City of Monterey, the Pacific Ocean, and the Del Monte Forest. Nicknamed "America's Last Hometown," attractions include Victorian homes and an award-winning natural history museum. Local public schools are ranked highest among all public schools on the Monterey Peninsula and the community has the lowest crime rate of any city in Monterey County. Natural resources include a monarch butterfly habitat sanctuary, sandy beaches, and the oldest continuously-operating lighthouse on the west coast. It is home to over 15 thousand residents in just over 4 square miles. Residents enjoy average summer temperatures of 71° F, dropping during the winter months to about 50° F. Although the community generally receives around 10 – 12 inches of rainfall during the winter months, relatively dry summers (<1 of rainfall per month) can pose an extra challenge to managing the water needs of a diverse urban forest. All trees play a role in supporting a positive and healthy environment. This analysis provides a snapshot of the community urban forest (publicly-owned trees) and benchmarks the current structure and benefits of this resource.

Individual trees and a healthy urban forest play an important role in the quality of life and the sustainability of every community. Research demonstrates that healthy urban trees can improve the local environment and diminish the impact resulting from urbanization and industry (Center for Urban Forest Research). Trees improve air quality by manufacturing oxygen and absorbing carbon dioxide (CO_2), as well as filtering and reducing airborne particulate matter such as smoke and dust. Urban trees reduce energy consumption by shading structures from solar energy and reducing the overall rise in temperature created through urban heat island effects (EPA). Trees slow and reduce stormwater runoff, helping to protect critical waterways from excess pollutants and particulates. In addition, urban trees provide critical habitat for wildlife and promote a connection to the natural world for city residents.

In addition to these direct improvements, healthy urban trees increase the overall attractiveness of a community and the value of local real estate by 7% to 10%. Trees promote shopping, retail sales, and tourism (Wolf, 2007). Trees support a more livable community, fostering psychological health, and providing residents with a greater sense of place (Ulrich, 1986; Kaplan, 1989). Community trees, both public and private, soften the urban hardscape by providing a green sanctuary, making Pacific Grove a more enjoyable place to live, work, and play. The City's community trees play a prominent role in the overall urban forest benefits afforded to the community. The Forestry Department has the responsibility to maintain a portion of the urban forest along with safeguarding the trees from unauthorized pruning or removal. The department oversees 7,394 trees on streets and in parks. Residents rely on the department to protect and maintain this vital resource.

To support the management of the community urban forest, an inventory of public trees was collected in 2015. The inventory collected the species, size, condition, and geographic location of each tree in an electronic, GIS format. An urban forest is a dynamic resource, constantly changing and growing in response to environment and care. Maintaining and updating this information will be critical for ongoing management.

The tree inventory data was analyzed with i-Tree's *Streets*, a STRATUM Analysis Tool (*Streets* v5.1.5; i-Tree v6.0.9), to develop a resource analysis and report of the existing condition of this urban forest. This report, unique to Pacific Grove, quantifies the value of the community's trees with

regard to actual benefits derived from the tree resource. In addition, the report provides baseline values that can be used to develop and update an urban forest management plan. Management plans help communities determine where to focus available resources and set benchmarks for measuring progress.

This analysis describes the structure, function, and value of Pacific Grove's community trees. With this information, managers and citizens can make informed decisions about tree management strategies. This report provides the following information:

- A description of the current structure of Pacific Grove's community tree resource and an established benchmark for future management decisions.
- The economic value of the benefits from the urban forest, illustrating the relevance and relationship of trees to local quality of life issues such as air quality, environmental health, economic development, and psychological health.
- Data that may be used by resource managers in the pursuit of alternative funding sources and collaborative relationships with utility purveyors, non-governmental organizations, air quality districts, federal and state agencies, legislative initiatives, or local assessment fees.
- Benchmark data for developing a long-term urban forest management plan.

Figure 1. Monarch Grove Sanctuary, with conifer and eucalyptus species that provide crucial habitat for the Monarch Butterfly.

Summary

Structure

Pacific Grove's community urban forest includes 7,394 public trees and 623 available planting sites on streets and in parks. A structural analysis is the first step towards understanding the benefits provided by these trees as well as their management needs. Considering species composition, diversity, age distribution, condition, canopy coverage, and replacement value, DRG determined that the following information characterizes this urban forest resource:

- More than 136 unique tree species were identified in the inventory. The predominant tree species are coast live oak (Quercus agrifolia, 30%), Monterey pine (Pinus radiata, 25%), and Monterey cypress (Cupressus macrocarpa, 21%). These native trees comprise 76% of the total population.
- Over half of the trees are between 6" – 18" DBH and a fifth are over 24", indicating a mix of young, established populations along with a mature population providing maximum benefits.
- 42% of trees are in good condition.
- Community trees are providing 134 acres of canopy cover, about 5% of the overall land area in Pacific Grove.
- To date, Community trees have sequestered 15,442 tons of carbon dioxide (CO_2), valued at $231,624.
- The current stocking level for the community urban forest is 92.2%, based on a total 8,017 suitable planting sites, including 7,394 trees and 623 vacant sites and stumps.
- Replacement of Pacific Grove's 7,394 community trees with trees of similar size, species, and condition would cost nearly $26.3 million.

Benefits

Annually, Pacific Grove's community trees provide cumulative benefits to the community at an average value of $166 per tree, for a total gross value of nearly $1.3 million per year (Appendix A). These benefits include:

- Community trees reduce electricity and natural gas use through shading and climate effects for an overall benefit of $176,195, an average of $23.83 per tree.
- Each year, community trees sequester a gross 910 tons of atmospheric CO2 for a net value of $17,704 and a net average of $2.39 per tree.
- Each year community trees remove 1.9 tons of air pollutants with a gross value of $39,085.
- Pacific Grove's community trees intercept over 14.2 million gallons of stormwater annually for a total value of almost $57,000, an average of $7.70 per tree.
- The benefits from Pacific Grove's community trees to property value, health, aesthetics, and socioeconomics is nearly $1.1 million, an average of $141.38 per tree.

- When the annual investment of $299,571 for the management of the community urban forest is considered, the annual net benefit (benefits minus investment) for the community is nearly $1.3 million, an average of $166 per tree. In other words, for every $1 invested in public trees, the community receives $4.11 in benefits.

Management

Pacific Grove's community urban forest is a dynamic resource that requires continued investment to maintain and realize its full benefit potential. Trees are one of the few community assets that have the potential to increase in value with time and proper management. Appropriate and timely tree care can substantially increase lifespan. When trees live longer, they provide greater benefits. As individual trees continue to mature and aging trees are replaced, the overall value of the community forest and the amount of benefits provided grow as well. This vital, living resource is, however, vulnerable to a host of stressors and requires ecologically sound and sustainable best management practices to ensure a continued flow of benefits for future generations.

The urban forest in Pacific Grove is an establishing resource in overall fair to good condition. With continued new tree planting, proactive management, and planning, the benefits from this resource will continue to increase as young trees mature. Young tree training, a regular pruning cycle, and regular inspection to identify structural and age-related defects is recommended to manage risk and reduce the likelihood of tree and branch failure. Additional maintenance recommendations, based on the 2015 inventory are provided in the Pacific Grove Inventory Summary, a companion document to this one. Based on this resource analysis, DRG recommends the following:

- Increase species diversity by insuring that new tree plantings include a variety of suitable species and don't unduly increase reliance on prevalent species.
- Increase the stocking level by using all available planting sites to improve diversity and increase benefits. Install large-stature species wherever space allows.
- Provide structural pruning for young trees and a regular pruning cycle for all trees.
- Protect existing trees, especially mature native species, and manage risk with regular inspection to identify and mitigate structural and age-related defects.
- Continue to maintain and update the inventory database, including tracking tree growth and condition during regular pruning cycles.
- For greater air quality benefits, new planting should include trees that emit less biogenetic organic compounds (BVOCs).

With adequate protection and planning, the value of the community urban forest resource in Pacific Grove will increase over time. Proactive management and a tree replacement plan are critical to ensuring that residents continue to receive a high return on their investment. Along with new tree installation and replacement planting, funding for tree maintenance and inspection is vital to preserving benefits, prolonging tree life, and managing risk. Existing mature trees should be maintained and protected whenever possible since the greatest benefits accrue from the continued growth and longevity of the existing canopy. Managers can take pride in knowing that community trees support the quality of life for residents and neighboring communities.

Pacific Grove's Urban Forest Resource

An urban forest is more thoroughly understood through examination of composition and species richness (diversity). Consideration of stocking level (trees per total available space), canopy cover, age distribution, condition, and performance provide a foundation for planning and management strategies. Inferences based on this data can help managers understand the importance of individual tree species to the overall forest as it exists today and provide a basis to project the future potential of the resource.

Population Composition

Conifer species are a staple species in Pacific Grove's coastal community urban forest, comprising 49% of the total inventory. Not only do conifers capture large amounts of stormwater during the winter months when it typically rains, but they help create a sense of place for the community.

Broadleaf evergreen species make up 45% of the tree population, including 33% large-stature, 8% medium-stature, and 4% small-stature trees. Broadleaf deciduous trees comprise 5% of the population, including 1% large-stature, 1% medium-stature, and 2% small-stature species. Conifers species make up more than 49% of the population, including 49% large-stature, 0.27% medium-stature, and 0.09% small-stature species. Palms comprise 1% of the total population.

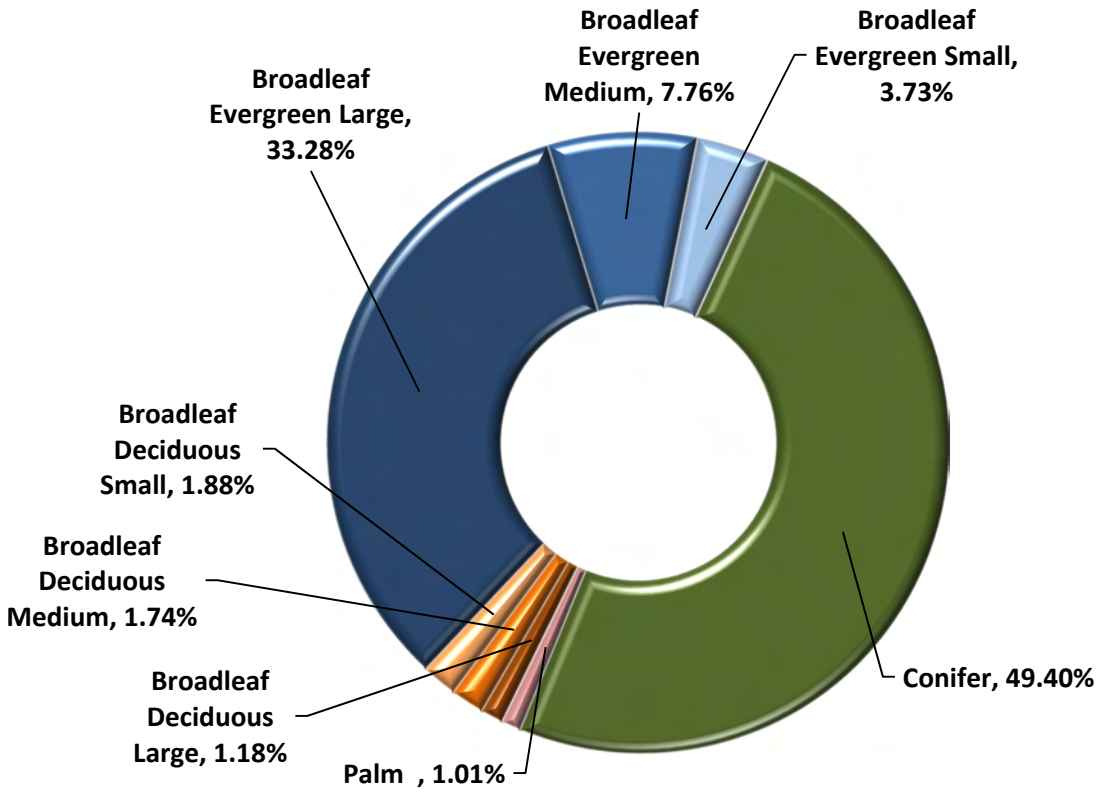

Figure 2. Composition of Tree Type and Stature in Pacific Grove's Community Urban Forest

Species Richness and Composition

The community tree resource in Pacific Grove is composed of a wide variety of more than 136 unique species (Table 1 and Appendix C). That's much greater than the mean of 53 species reported by McPherson and Rowntree (1989) in their nationwide survey of street tree populations in 22 U.S. cities.

The top 3 species in Pacific Grove represent over 75% of the overall population (Figure 3). The predominant tree species are coast live oak (*Quercus agrifolia*, 30%), Monterey pine (*Pinus radiata*, 25%), and Monterey cypress (*Cupressus macrocarpa*, 21%). There is a widely accepted rule that no single species should represent greater than 10% of the total population, and no single genus more than 20% (Clark Et al, 1997). Even though these species far exceed that rule, they are native to the region and reinforce the special character that is unique to the City.

Maintaining diversity in an urban forest is important. Dominance of any single species or genus can have detrimental consequences in the event of storms, drought, disease, pests, or other stressors that can severely affect an urban forest and the flow of benefits and costs over time. Catastrophic pathogens, such as Dutch Elm Disease (*Ophiostoma ulmi*), Emerald Ash Borer (*Agrilus planipennis*), Asian Longhorned Beetle (*Anoplophora glabripennis*), and Sudden Oak Death (SOD) (*Phytophthora ramorum*) are some examples of unexpected, devastating, and costly pests and pathogens that highlight the importance of diversity and the balanced distribution of species and genera.

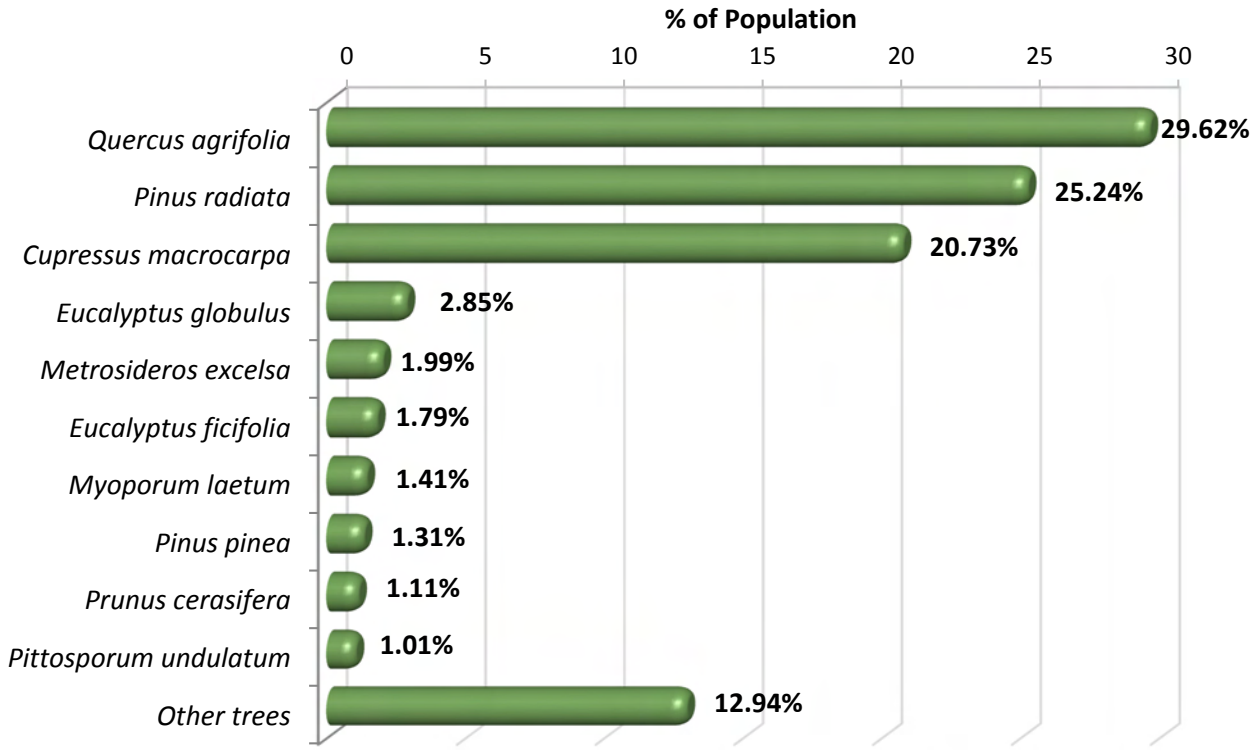

Figure 3. Ten Most Prevalent Species in Pacific Grove's Community Urban Forest

Table 1. Population Summary of Pacific Grove's Community Urban Forest (Species representing >1%)

Species	DBH Class (in)										
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42	Total	%of Pop
Broadleaf Deciduous Small (BDS)											
Prunus cerasifera	31	34	17	0	0	0	0	0	0	**82**	**1.11**
Other BDS Trees	30	16	9	1	1	0	0	0	0	**57**	**0.77**
BDS Total	**61**	**50**	**26**	**1**	**1**	**0**	**0**	**0**	**0**	**139**	**1.88%**
Broadleaf Evergreen Large (BEL)											
Quercus agrifolia	37	168	925	681	237	82	34	15	11	**2,190**	**29.62**
Eucalyptus globulus	0	5	48	25	20	16	13	21	63	**211**	**2.85**
Other BEL Trees	6	3	7	6	20	11	5	2	0	**60**	**0.81**
BEL Total	**43**	**176**	**980**	**712**	**277**	**109**	**52**	**38**	**74**	**2,461**	**33.28%**
Broadleaf Evergreen Medium (BEM)											
Metrosideros excelsa	6	27	45	39	20	10	0	0	0	**147**	**1.99**
Eucalyptus ficifolia	0	1	11	25	46	21	19	6	3	**132**	**1.79**
Pittosporum undulatum	6	25	37	6	1	0	0	0	0	**75**	**1.01**
Other BEM Trees	30	64	85	26	6	2	6	1	0	**220**	**2.97**
BEM Total	**42**	**117**	**178**	**96**	**73**	**33**	**25**	**7**	**3**	**574**	**7.76%**
Broadleaf Evergreen Small (BES)											
Myoporum laetum	1	22	67	13	1	0	0	0	0	**104**	**1.41**
Other BES Trees	17	45	84	20	5	1	0	0	0	**172**	**2.32**
BES Total	**18**	**67**	**151**	**33**	**6**	**1**	**0**	**0**	**0**	**276**	**3.73%**
Conifer Evergreen Large (CEL)											
Pinus radiata	159	112	373	393	342	245	127	74	41	**1,866**	**25.24**
Cupressus macrocarpa	60	114	291	280	216	155	112	96	209	**1,533**	**20.73**
Pinus pinea	7	15	33	33	8	1	0	0	0	**97**	**1.31**
Other CEL Trees	20	32	32	17	16	3	6	2	2	**130**	**1.76**
CEL Total	**246**	**273**	**729**	**723**	**582**	**404**	**245**	**172**	**252**	**3,626**	**49.04%**
Grand Total	**445**	**750**	**2,154**	**1,612**	**965**	**564**	**337**	**234**	**333**	**7,394**	**100%**

Species Importance

To quantify the significance of any one particular species in Pacific Grove's community tree inventory an importance value is derived for each of the most common species. Importance values are particularly meaningful to urban forest managers because they indicate a reliance on the functional capacity of a particular species. i-Tree *Streets* calculates importance value based on the mean of three values: percentage of total population, percentage of total leaf area, and percentage of total canopy cover. Importance value goes beyond tree numbers alone to suggest reliance on specific species based on the benefits they provide. The importance value can range from zero (which implies no reliance) to 100 (suggesting total reliance).

No single species should dominate the composition of an urban forest population. Since the importance value goes beyond population numbers alone, it can help managers to better comprehend the resulting loss of benefits from a catastrophic loss of any one species. When importance values are comparatively equal among the 10 most abundant species, the risk of major reductions to benefits is significantly reduced. Of course, suitability of the dominant species is another important consideration. Planting short-lived or poorly adapted species can result in shorter lifespans and increased long-term management investments.

The 10 most abundant species (>1% of the population) represent 87% of the overall population, 93% of the total leaf area, and 92% of the total canopy cover for a combined importance value of 90.69 (Table 2). Of these Pacific Grove relies most on coast live oak (*Quercus agrifolia*, IV=26.85), Monterey pine (*Pinus radiata*, IV=26.03) and Monterey cypress (*Cupressus macrocarpa*, IV=25.74).

These three native species dominate the landscape. The two large-stature conifers have both a young and established population. The coast live oak (*Quercus agrifolia*) has a high population of young trees. These species should be carefully maintained as to not lose the character they give the City and to maintain their high importance values.

Due to their large stature and high leaf surface area, some species provide more impact than their population numbers alone would suggest. For example, blue gum (*Eucalyptus globulus*) represents 3% of the population but 6% of canopy cover. These are mature populations of large-stature trees with substantial numbers of established trees.

The low importance value of some species is a function of tree type. Immature and small-stature populations tend to have lower importance values than their percentage in the overall population might suggest. This is due to their relatively small leaf area and canopy coverage. For instance, myoporum (*Myoporum laetum*) represents 2% of the population but the importance value of the species is 0.92%. In contrast, Italian stone pine (*Pinus pinea*), which represent 1% of the population and an importance value of 0.93% is a large-stature stature species with 91% of the population less than 18 inches in diameter (DBH). The importance value of this species will increase as trees mature.

Table 2. Importance Value of Pacific Grove's Most Prevalent Community Tree Species (representing >1%)

Species	Number of Trees	% of Pop	Leaf Area (ft2)	% of Total Leaf Area	Canopy Cover (ft2)	% of Total Canopy Cover	Importance Value
Quercus agrifolia	2,190	29.62	5,337,707	25.80	1,466,293	25.13	**26.85**
Pinus radiata	1,866	25.24	5,647,538	27.29	1,491,411	25.56	**26.03**
Cupressus macrocarpa	1,533	20.73	5,741,270	27.75	1,677,091	28.74	**25.74**
Eucalyptus globulus	211	2.85	1,349,090	6.52	367,153	6.29	**5.22**
Metrosideros excelsa	147	1.99	171,248	0.83	84,965	1.46	**1.42**
Eucalyptus ficifolia	132	1.79	635,412	3.07	167,016	2.86	**2.57**
Myoporum laetum	104	1.41	120,739	0.58	45,073	0.77	**0.92**
Pinus pinea	97	1.31	172,052	0.83	38,162	0.65	**0.93**
Prunus cerasifera	82	1.11	29,652	0.14	11,528	0.20	**0.48**
Pittosporum undulatum	75	1.01	41,393	0.20	19,030	0.33	**0.51**
Other Trees	957	12.94	1,445,087	6.98	467,299	8.01	**9.31**
All Trees	**7,394**	**100%**	**20,691,187**	**100%**	**5,835,020**	**100%**	**100**

Canopy Cover

The amount and distribution of leaf surface area is the driving force behind the urban forest's ability to produce benefits for the community (Clark, 1997). As canopy cover increases, so do the benefits afforded by leaf area. The City of Pacific Grove encompasses an area of 2,560 acres. Overall, community trees provide approximately 134 acres of canopy cover, or 5% of the City's total area.

Stocking Level

Pacific Grove's community urban forest currently includes 623 available planting sites, including 351 vacant sites and 272 stumps. Considering the public tree inventory identified a total of 8,017 planting sites with 7,394 existing trees, the current stocking level of the community forest is 92.2%. However, the inventory identified 174 trees that are recommended for Priority 1 removal and 544 trees that are recommended for Priority 2 removal over the next few years. A tree planting strategy to increase the stocking level, maximize the use of available planting sites, and maintain the benefit stream the urban forest is providing is outlined in the Inventory Summary Report (2015).

Relative Age Distribution

Age distribution can be approximated by considering the DBH range of the overall population and of individual species. Trees with smaller diameters tend to be younger. It is important to note that palms do not increase in DBH over time, so they are not considered in this analysis. In palms, height more accurately correlates to age.

The distribution of individual tree ages within a tree population influences present and future costs as well as the flow of benefits. An ideally-aged population allows managers to allocate annual maintenance costs uniformly over many years and assures continuity in overall tree canopy coverage and associated benefits. A desirable distribution has a high proportion of young trees to offset establishment and age related mortality as the percentage of older trees declines over time (Richards, 1982/83). This ideal, albeit uneven, distribution suggests a large fraction of trees (~40%) should be young, with diameters (DBH) less than eight inches, while only 10% should be in the large diameter classes (>24 inches DBH).

The age distribution of Pacific Grove's community urban forest is nearly ideal, with 37% of trees 8 inches or less in diameter (DBH) and 20% of trees larger than 24 inches in diameter (Figure 4). With ongoing proactive management this resource will continue to produce a stable benefit stream, supporting the quality of life and health of the community and the environment. The City has a fairly large population of established trees (6" to 12" inch DBH. With regular inspection and proactive management, these trees have the potential to increase in the benefits they provide over time.

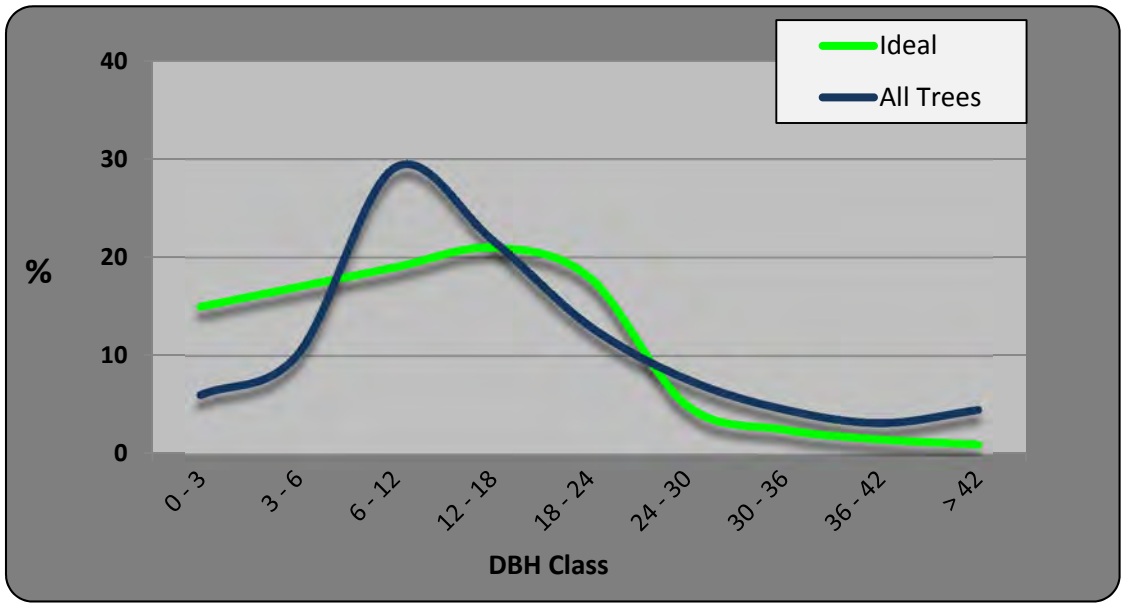

Figure 4. Age Distribution of Pacific Grove's Community Urban Forest

Of the ten most common species in Pacific Grove's community urban forest, the youngest population is purple leaf plum (*Prunus cerasifera*). Nearly 38% of these trees are 3 inches or less in diameter. This suggests that recent tree plantings have increased the prevalence of this species. Blue gum (*Eucalyptus globulus*), Monterey cypress (Cupressus macrocarpa), and red flowering gum (*Eucalyptus ficifolia*) are the most mature populations with the greatest representation of trees greater than 24 inches in diameter.

Italian stone pine (*Pinus pinea*), New Zealand Christmas tree (*Metrosideros excelsa*), myoporum (*Myoporum laetum*), purple leaf plum (*Prunus cerasifera*), and Victorian box (*Pittosporum undulatum*) are also well established species. Of these, only Victorian box and purple leaf plum have significant representation in the smaller class sizes, with 41% of Victorian box and 79% of purple leaf plum between 1 and 6 inches diameter.

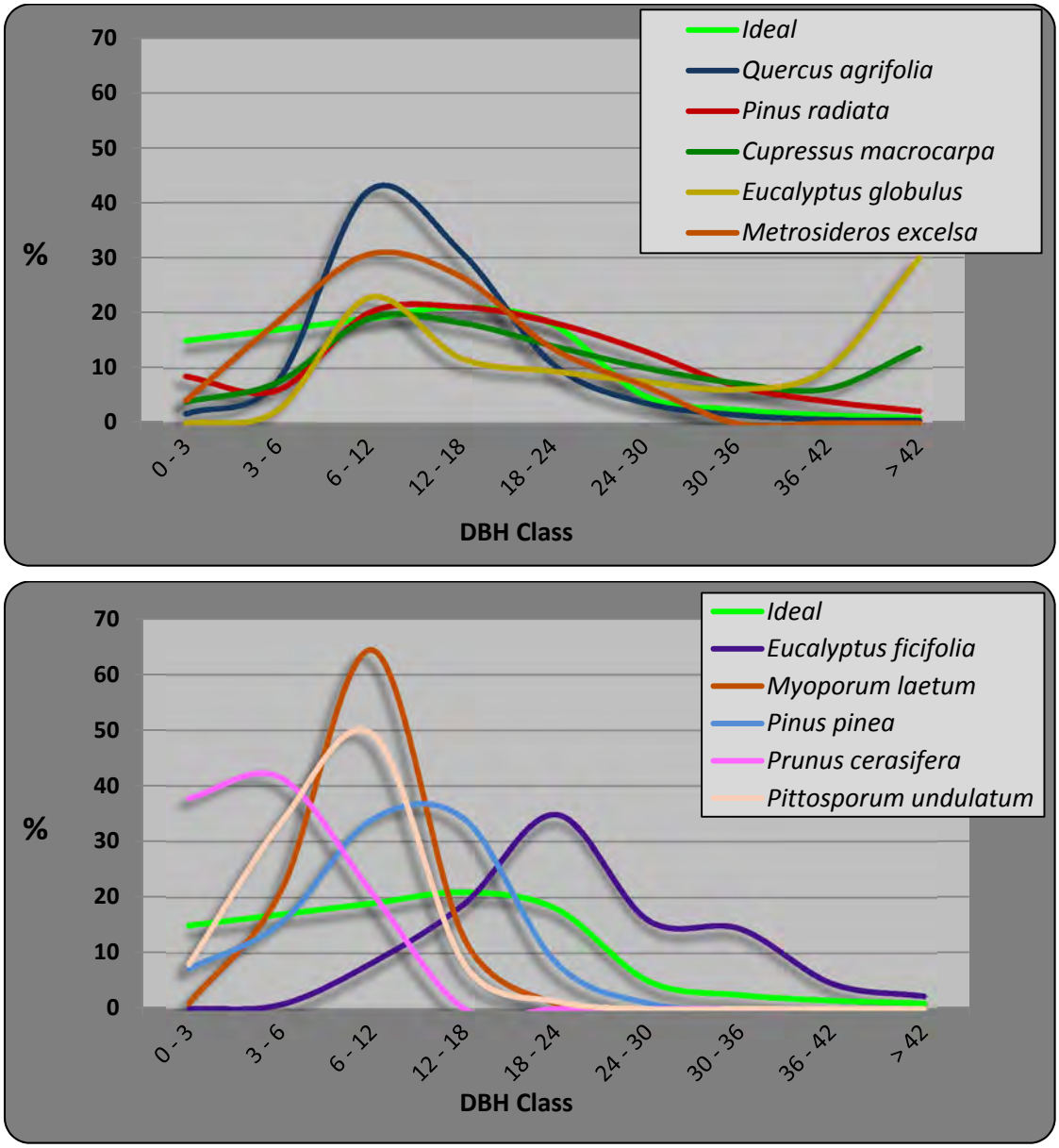

Figure 5. Age Distribution of the Top 10 Tree Species

Urban Forest Condition

Tree condition is an indication of how well trees are managed and how well they are performing in a given site-specific environment (e.g., street, median, parking lot, etc.). Condition ratings can help urban forest managers anticipate maintenance and funding needs. In addition, tree condition is an important factor for the calculation of urban forest benefits. A condition rating of good assumes that a tree has no major structural problems, no significant mechanical damage, and may have only minor aesthetic, insect, disease, or structural problems, and is in good health.

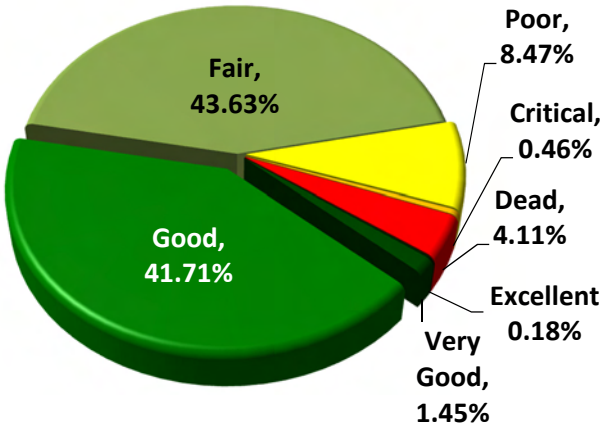

Figure 6. Condition of Pacific Grove's Community Urban Forest

Pacific Grove's community forest is overall relatively young and in fair to good condition with 42% good and 44% fair trees (Figure 6). About 13% of Pacific Grove's community trees are poor, dead, or in critical condition

The *relative performance index* (RPI) is one way to further analyze the condition and suitability of specific tree species. The RPI provides an urban forest manager with a detailed perspective on how different species perform compared to each other. The index compares the condition ratings of each tree species with the condition ratings of every other tree species within the population. An RPI of 1.0 or better indicates that the species is performing as well or better than average. An RPI value below 1.0 indicates that the species is not performing as well in comparison to the rest of the population.

Among the 10 most common species included in this inventory, 8 have an RPI of 1.0 or greater (Table 3). Of these, New Zealand Christmas tree (*Metrosideros excelsa*) and blue gum (*Eucalyptus globulus*) have the highest RPI with 1.12, while Monterey pine (*Pinus radiata* RPI=0.91) and myoporum (*Myoporum laetum,* RPI=0.90) have the lowest.

The RPI can be a useful tool for urban forest managers. For example, if a community has been planting two or more new species, the RPI can be used to compare their relative performance. If the RPI indicates that one is performing relatively poorly, managers may decide to reduce or even stop planting that species and subsequently save money on both planting stock and replacement costs. The RPI enables managers to look at the performance of long-standing species as well. Established species with an RPI of 1.00 or greater have performed well when compared to the population as a whole. These top performers should be retained, and planted, as a healthy proportion of the overall population. It is important to keep in mind that, because RPI is based on condition at the time of the inventory, it may not reflect cosmetic or nuisance issues, especially seasonal issues that are not threatening the health or structure of the trees.

An RPI value less than 1.00 may be indicative of a species that is not well adapted to local conditions. Poorly adapted species are more likely to present increased safety and maintenance issues. Species with an RPI less than 1.00 should receive careful consideration before being selected for future planting choices. However, prior to selecting or deselecting trees based on RPI alone, managers should consider the age distribution of the species, among other factors. A species that

has an RPI of less than 1.00, but has a significant number of trees in larger DBH classes, may simply be exhibiting signs of population senescence. A complete table, with RPI values for all species, is included in Appendix C.

Table 3. Relative Performance Index for Pacific Grove's Most Prevalent Species (representing>1%)

Species	Dead or Dying (%)	Poor (%)	Fair (%)	Good (%)	Very Good (%)	N/A (%)	RPI	# of Trees	% of Pop
Quercus agrifolia	0.78	10.64	49.95	38.36	0.09	0.18	**1.00**	2,190	29.62
Pinus radiata	11.36	10.50	40.89	32.48	3.91	0.86	**0.91**	1,866	25.24
Cupressus macrocarpa	3.65	5.81	40.51	47.49	1.17	1.37	**1.03**	1,533	20.73
Eucalyptus globulus	0.47	1.90	36.49	61.14	0.00	0.00	**1.12**	211	2.85
Metrosideros excelsa	0.00	1.36	39.46	57.14	1.36	0.68	**1.12**	147	1.99
Eucalyptus ficifolia	0.00	5.30	62.88	31.82	0.00	0.00	**1.00**	132	1.79
Myoporum laetum	5.77	21.15	38.46	33.65	0.00	0.96	**0.90**	104	1.41
Pinus pinea	3.09	4.12	31.96	60.82	0.00	0.00	**1.10**	97	1.31
Prunus cerasifera	0.00	12.20	32.93	54.88	0.00	0.00	**1.07**	82	1.11
Pittosporum undulatum	0.00	2.67	46.67	49.33	1.33	0.00	**1.09**	75	1.01
Other Trees	0.94	5.96	41.48	50.05	1.15	0.42	**1.05**	957	12.94
Total	**4.11%**	**8.47%**	**43.63%**	**41.71%**	**1.45%**	**0.64%**	**1.00**	**7,394**	**100%**

The RPI value can also help to identify underused species that are demonstrating good performance. Trees with an RPI value greater than 1.00 and an established age distribution may be indicating their suitability in the local environment and should receive consideration for additional planting (Table 4).

Although there are only 6 California bay trees (*Umbellularia californica*) in the inventory, they are native to the region and would naturally thrive. This species may be appropriate for additional planting. Sweetgum (*Liquidambar styraciflua*), is sometimes considered a nuisance because of its spiked fruit. However, the cultivar, *Liquidambar styraciflua* 'Rotundiloba' is fruitless and can be a suitable substitute. Coast redwood (*Sequoia sempervirens*) is another native species, and performs very well in coastal environments. However, these trees need ample growing space when planted.

When considering new species based on RPI, it is important to base the decision on established populations. The greater number of trees of a particular species, the more relevant the RPI becomes. The following species appear to be performing well and should be considered for future tree plantings:

Table 4. Species That May Be Underused (based on RPI and age distribution)

Species	RPI	# of Trees	% of Pop
Broadleaf Deciduous Large			
Platanus hybrida	**1.06**	35	0.47
Broadleaf Deciduous Medium			
Liquidambar styraciflua	**1.11**	43	0.58
Betula pendula	**1.06**	12	0.16
Robinia x ambigua	**1.06**	12	0.16
Broadleaf Evergreen Large			
Podocarpus gracilior	**1.28**	9	0.12
Umbellularia californica	**1.16**	6	0.08
Broadleaf Evergreen Medium			
Maytenus boaria	**1.03**	47	0.64
Conifer Evergreen Large			
Sequoia sempervirens	**1.07**	68	0.92
Pinus torreyana	**1.25**	22	0.30

Replacement Value

The current value of the community urban forest in Pacific Grove is over $26.2 million (Table 5). The replacement value accounts for the historical investment in trees over their lifetime. The replacement value is also a way of describing the value of a tree population (and/or average value per tree) at a given time. The replacement value reflects current population numbers, stature, placement, and condition. There are several methods available for obtaining a fair and reasonable perception of a tree's value (CTLA, 1992; Watson, 2002). The cost approach, trunk formula method used in this analysis assumes the value of a tree is equal to the cost of replacing the tree in its current state (Cullen, 2002).

To replace Pacific Grove's 7,394 community trees with trees of similar size, species, and condition would cost over $26.2 million. The average replacement value per tree is $3,546. Monterey cypress (*Cupressus macrocarpa*) and coast live oak (*Quercus agrifolia*) are the most valuable populations representing $19.1 million, 73% of the overall replacement value and 55% of the overall urban forest resource.

Pacific Grove's community trees represent a vital component of the City's infrastructure and a public asset valued at over $26.2 million—an asset that, with proper care and maintenance, will continue to increase in value over time. Distinguishing the replacement value from the value of annual benefits produced by this urban forest resource is very important.

Figure 7. Replacement of the entire Monterey cypress population in Pacific Grove's public inventory would cost nearly 12.2 million.

Table 5. Summary of Replacement Value for Pacific Grove's Community Urban Forest Resource

Species	DBH Class (in)									Total $	% of Total	% of Pop
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42			
Quercus agrifolia	4,975	72,914	1,230,507	2,289,327	1,503,928	825,716	508,650	235,464	225,767	**6,897,250**	26.30	29.62
Pinus radiata	26,524	24,285	157,031	353,381	559,926	663,295	486,112	356,021	238,850	**2,865,426**	10.93	25.24
Cupressus macrocarpa	10,960	49,438	400,793	966,100	1,400,879	1,619,070	1,547,144	1,880,159	4,309,268	**12,183,810**	46.46	20.73
Eucalyptus globulus	0	945	14,217	13,250	16,114	20,413	20,137	47,504	159,759	**292,339**	1.11	2.85
Metrosideros excelsa	1,114	20,648	114,782	258,614	259,417	214,631	0	0	0	**869,206**	3.31	1.99
Eucalyptus ficifolia	0	366.16	14,416	74,195	300,854	235,859	281,463	115,531	60,354	**1,083,038**	4.13	1.79
Myoporum laetum	45	3,684	34,064	17,127	2,985	0	0	0	0	**57,907**	0.22	1.41
Pinus pinea	839	4,736	30,717	79,499	41,449	8,804	0	0	0	**166,046**	0.63	1.31
Prunus cerasifera	5,351	11,757	11,978	0	0	0	0	0	0	**29,086**	0.11	1.11
Pittosporum undulatum	894	14,845	71,754	35,542	8,527.77	0	0	0	0	**131,564**	0.50	1.01
Other Trees	23,375	95,244	352,272	342,562	267,612	152,183	205,934	147,224	60,119	**1,646,527**	6.28	12.94
All Trees	**$74,077**	**$298,862**	**$2,432,531**	**$4,429,597**	**$4,361,692**	**$3,739,971**	**$3,049,440**	**$2,781,903**	**$5,054,117**	**$26,222,199**	**100%**	**100%**

Benefits from Pacific Grove's Community Urban Forest

Trees are important to Pacific Grove. Environmentally, they help conserve and reduce energy use, reduce global carbon dioxide (CO_2) levels, improve air quality, and mitigate stormwater runoff. Additionally, trees provide a wealth of well-documented psychological, social, and economic benefits related primarily to their aesthetic effects. Environmentally, trees make good sense, providing benefits back to the community. However, the question remains, are the collective benefits worth the cost of management? In other words, are community trees a good investment for Pacific Grove? To answer this question, the benefits must be quantified in financial terms.

The i-Tree *Streets* analysis model allows benefits to be quantified based on regional reference cities and local community attributes, such as median home values and local energy prices. This analysis provides a snapshot of the annual benefits (along with the value of those benefits) produced by Pacific Grove's community urban forest. While the annual benefits produced by the urban forest can be substantial, it is important to recognize that the greatest benefits are derived from the benefit stream that results over time, from a mature forest where trees are well managed, healthy, and long-lived.

This analysis used current inventory data for Pacific Grove's community trees and i-Tree's *Streets* software to assess and quantify the beneficial functions of this resource and to place a dollar value on the annual environmental benefits these trees provide. The benefits calculated by i-Tree *Streets* are estimations based on the best available and current scientific research with an accepted degree of uncertainty. The data returned from i-Tree *Streets* can provide a platform from which informed management decisions can be made (Maco and McPherson, 2003). A discussion on the methods used to calculate and assign a monetary value to these benefits is included in Appendix A.

Energy Savings

Trees modify climate and conserve energy in three principal ways:

- Shading reduces the amount of radiant energy absorbed and stored by hardscape surfaces, thereby reducing the heat island effect.
- Transpiration converts moisture to water vapor, thereby cooling the air by using solar energy that would otherwise result in heating of the air.
- Reduction of wind speed and the movement of outside air into interior spaces and conductive heat loss where thermal conductivity is relatively high (e.g., glass windows) (Simpson, 1998).

The *heat island effect* describes the increase in urban temperatures in relation to surrounding suburban and rural areas. Heat islands are associated with an increase in hardscape and impervious surfaces. Trees and other vegetation within an urbanized environment help reduce the heat island effect by lowering air temperatures 5°F (3°C) compared with outside the green space (Chandler, 1965). On a larger citywide scale, temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy coverage and more vegetated suburban areas (Akbari and others, 1992). The relative importance of these effects depends upon the size

and configuration of trees and other landscape elements (McPherson, 1993). Tree spacing, crown spread, and vertical distribution of leaf area each influence the transport of warm air and pollutants along streets and out of urban canyons. Trees reduce conductive heat loss from buildings by reducing air movement into buildings and against conductive surfaces (e.g., glass, metal siding). Trees can reduce wind speed and the resulting air infiltration by up to 50%, translating into potential annual heating savings of 25% (Heisler, 1986).

Electricity and Natural Gas Reduction

Electricity and natural gas saved annually in Pacific Grove from both the shading and climate effects of community trees is equal to 996 MWh (valued at $149,410) and 20,329 therms ($26,785), for a total retail savings of approximately $176,195 and an average of $23.83 per tree (Table 6). The species that contribute most to energy benefits on a per-tree basis are large-stature broadleaf evergreens including blue gum (*Eucalyptus globulus*), with an average value of $41.49 and red flowering gum (*Eucalyptus ficifolia*) with an average value of $39.06 per tree.

Small-canopy trees are less able to provide electricity and natural gas reduction benefits. On a per-tree basis, purple leaf plum (*Prunus cerasifera)* provides $4.17 in average benefits and it is providing just 0.19% of the energy benefits. This is a small-statured tree with 79% of its population less than 6 inches DBH. Victorian box (*Pittosporum undulatum*) provides only $6.03 in average benefits while providing 0.26% of the energy benefits. This is a medium-stature tree with 91% of its population less than 12 inches DBH. However, these energy benefits should increase over time as this younger medium-stature population matures.

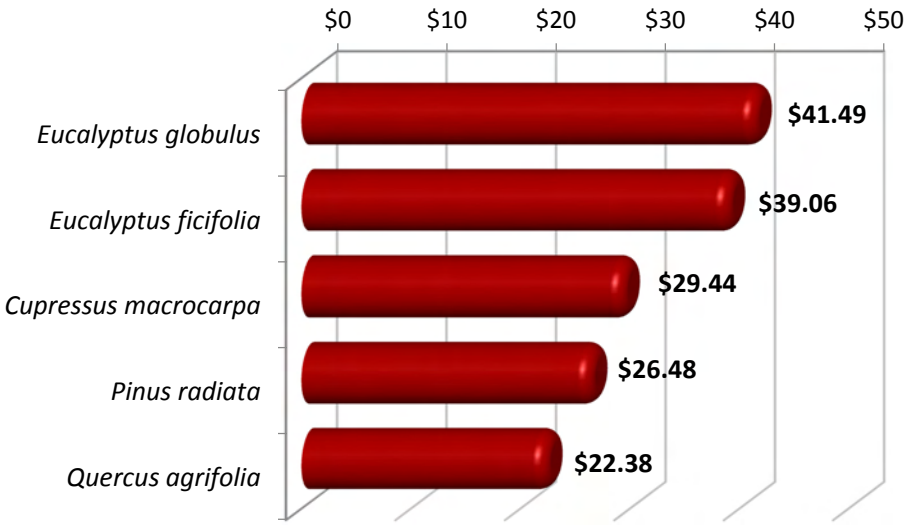

Figure 8. Top Five Species for Per-Tree Annual Electricity and Natural Gas Benefits

Figure 9. Public Trees provide $176,195 in total annual energy savings in Pacific Grove.

Table 6. Annual Electric and Natural Gas Benefits from Pacific Grove's Community Urban Forest

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	% of Pop	% of Total $	Avg. $/tree
Quercus agrifolia	275.68	41,352	5,814	7,660	**49,012**	29.62	27.82	**22.38**
Pinus radiata	278.12	41,718	5,841	7,696	**49,414**	25.24	28.04	**26.48**
Cupressus macrocarpa	257.63	38,645	4,923	6,487	**45,132**	20.73	25.61	**29.44**
Eucalyptus globulus	50.19	7,528	930	1,226	**8,754**	2.85	4.97	**41.49**
Metrosideros excelsa	9.49	1,423	152	199	**1,623**	1.99	0.92	**11.04**
Eucalyptus ficifolia	28.59	4,289	658	867	**5,156**	1.79	2.93	**39.06**
Myoporum laetum	7.20	1,080	148	194	**1,275**	1.41	0.72	**12.26**
Pinus pinea	9.69	1,453	215	283	**1,736**	1.31	0.99	**17.90**
Prunus cerasifera	1.93	289	39	52	**341**	1.11	0.19	**4.17**
Pittosporum undulatum	2.65	398	41	54	**452**	1.01	0.26	**6.03**
Other Trees	74.89	11,233	1,567	2,065	**13,298**	12.94	7.55	**13.90**
All Trees	**996.06**	**$149,408**	**20,328**	**$26,783**	**$176,193**	**100%**	**100%**	**$23.83**

Atmospheric Carbon Dioxide Reduction

As environmental awareness continues to increase, governments are paying particular attention to global warming and the effects of greenhouse gas (GHG) emissions. As energy from the sun (sunlight) strikes the Earth's surface it is reflected back into space as infrared radiation (heat). Greenhouse gases absorb some of this infrared radiation and trap heat in the atmosphere, modifying the temperature of the Earth's surface. Many chemical compounds in the Earth's atmosphere act as GHGs, including methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), water vapor, and human-made (gases/aerosols). As GHGs increase, the amount of energy radiated back into space is reduced, and more heat is trapped in the atmosphere. An increase in the average temperature of the earth may result in changes in weather, sea levels, and land-use patterns, commonly referred to as "climate change." In the last 150 years, since large-scale industrialization began, the levels of some GHGs, including CO_2, have increased by 25 percent (U.S. Energy Information Administration).

California's Global Warming Solutions Act (AB 32), passed in 2006, set the 2020 GHG emissions reduction goal into law. In December 2007, the California Air Resources Board (ARB) approved the 2020 emission limit of 427 million metric tons of carbon dioxide equivalent (CO_2). As of 2007, regulations require that the largest industrial sources of GHG must report and verify their emissions. In 2011, the ARB adopted the cap-and-trade regulation. Under a cap-and-trade system, an upper limit (or cap) is placed on GHG emissions. This cap can be applied to any source, industry, region, or other jurisdictional level (e.g., state, national, global). Regulated entities are required to either reduce emissions to required limits or purchase (trade) emissions offsets in order to meet the cap. In 2011, the ARB approved four offset protocols for issuing carbon credits under cap-and-trade including the Forest Offset Protocol (ARB, 2011). This Protocol recognizes the important role forests play in fighting climate change.

The Center for Urban Forest Research (CUFR) recently led the development of Urban Forest Project Reporting Protocol. The protocol, which incorporates methods of the Kyoto Protocol and Voluntary Carbon Standard (VCS), establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides urban forest managers in developing tree planting and stewardship projects that could be registered for GHG reduction credits (offsets). The protocol can be applied to urban tree planting projects within municipalities, campuses, and utility service areas anywhere in the United States.

While the urban forest in Pacific Grove may or may not qualify for carbon-offset credits or be traded in the open market, the City's trees are nonetheless providing a significant reduction in atmospheric carbon dioxide (CO_2) for a positive environmental and financial benefit to the community.

Urban trees reduce atmospheric CO_2 in two ways:

- Directly, through growth and the sequestration of CO_2 in wood, foliar biomass, and soil.
- Indirectly, by lowering the demand for heating and air conditioning, thereby reducing the emissions associated with electric power generation and natural gas consumption.

At the same time, vehicles and other combustion engines used to plant and care for trees release CO_2 during operation. Additionally, when a tree dies, most of the CO_2 that accumulated as woody biomass is released back into the atmosphere during decomposition, except in cases where the

wood is recycled. Each of these factors must be considered when calculating the net CO_2 benefits of trees.

Sequestered Carbon Dioxide

To date, community trees in Pacific Grove have sequestered a total of 15,442 tons of carbon dioxide (CO_2), valued at $231,624 [1]. Annually, all community trees directly sequester an additional 910 tons of CO_2, valued at $13,655, into woody and foliar biomass. Accounting for estimated CO_2 emissions from tree decomposition (-148 tons), tree related maintenance activity (-0.43 tons), and avoided CO_2 (419 tons), Pacific Grove's community trees provide an annual net reduction in atmospheric CO_2 of 1,180 tons, valued at $17,704, with an average value of $2.39 per tree (Table 7).

Of prevalent species (representing >1% of the overall resource) blue gum (*Eucalyptus globulus*, $7.90/tree) and red flowering gum (*Eucalyptus ficifolia* $7.31/tree) currently provide the highest annual per tree benefit (Figure 10). The population of coast live oak (*Quercus agrifolia*) provide the highest amount of annual carbon benefits, valued at $5,278, 30% of the total benefit.

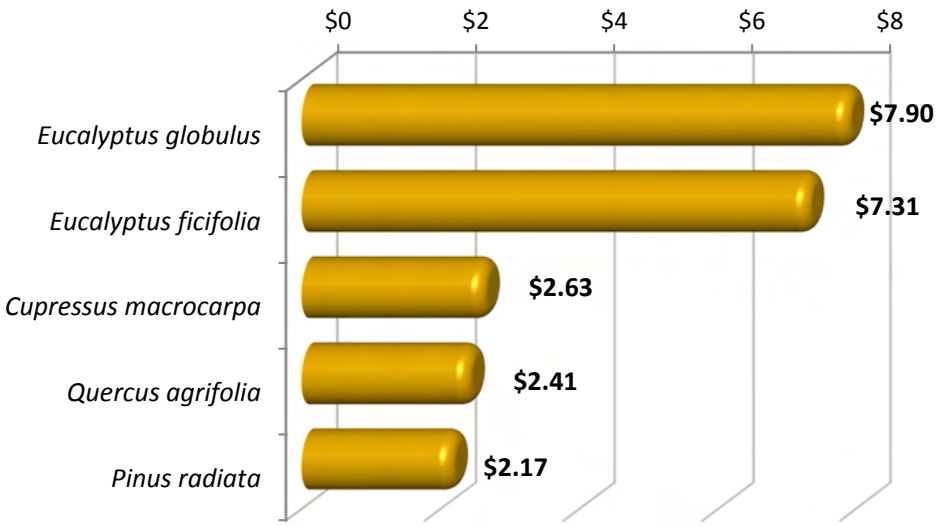

Figure 10. Top 5 Species for Per-Tree Annual Carbon Benefits

[1] Based on i-Tree *Streets* default value of $0.0075. Market value may vary.

Table 7. Summary of Annual Carbon Benefits from Pacific Grove's Community Tree Resource

Species	Sequestered (lb.)	Sequestered ($)	Decomposition Release (lb.)	Maintenance Release (lb.)	Total Release ($)	Avoided (lb.)	Avoided ($)	Net Total (lb.)	Total ($)	% of Pop	% of Total $	Avg. $/tree
Quercus agrifolia	542,973	4,072	- 70,663	- 257.53	- 531.91	231,735	1,738	703,787	**5,278**	29.62	29.81	**2.41**
Pinus radiata	359,711	2,698	- 54,543	- 219.43	- 410.72	233,784	1,753	538,733	**4,040**	25.24	22.82	**2.17**
Cupressus macrocarpa	397,704	2,983	- 77,535	- 180.27	- 582.87	216,564	1,624	536,552	**4,024**	20.73	22.73	**2.63**
Eucalyptus globulus	233,980	1,755	- 54,005	- 24.81	- 405.23	42,187	316	222,137	**1,666**	2.85	9.41	**7.90**
Metrosideros excelsa	14,086	106	- 2,677	- 17.29	- 20.21	7,974	60	19,366	**145**	1.99	0.82	**0.99**
Eucalyptus ficifolia	122,135	916	- 17,532	- 15.52	- 131.60	24,033	180	128,621	**965**	1.79	5.45	**7.31**
Myoporum laetum	5,036	38	- 419	- 12.23	- 3.24	6,054	45	10,658	**80**	1.41	0.45	**0.77**
Pinus pinea	8,491	64	- 694	- 11.41	- 5.29	8,143	61	15,929	**119**	1.31	0.67	**1.23**
Prunus cerasifera	3,516	26	- 235	- 9.64	- 1.83	1,624	12	4,895	**37**	1.11	0.21	**0.45**
Pittosporum undulatum	3,662	27	- 386	- 8.82	- 2.96	2,231	17	5,498	**41**	1.01	0.23	**0.55**
Other Trees	129,332	970	- 17,789	- 112.54	- 134.26	62,950	472	174,380	**1,308**	12.94	7.39	**1.37**
All Trees	**1,820,627**	**$13,655**	**- 296,479**	**- 869.49**	**-$2,230**	**837,278**	**$6,280**	**2,360,557**	**$17,704**	**100%**	**100%**	**$2.39**

Air Quality Improvement

Urban trees improve air quality in five fundamental ways:

- Absorption of gaseous pollutants such as ozone (O3), sulfur dioxide (SO2), and nitrogen dioxide (NO2) through leaf surfaces
- Interception of particulate matter (PM10), such as dust, ash, dirt, pollen, and smoke
- Reduction of emissions from power generation by reducing energy consumption
- Increase of oxygen levels through photosynthesis
- Transpiration of water and shade provision, resulting in lower local air temperatures, thereby reducing ozone (O3) levels

PM_{10} is particulate matter in the air that measures less than 10 micrometers, smaller than the width of a single human hair. These small particles or liquid droplets include smoke, soot, dust, and secondary reactions from gaseous pollutants. PM_{10} pollution is detrimental to health and can cause respiratory problems for local residents.

Ozone (O_3) is another air pollutant that is harmful to human health. Ozone forms when nitrogen oxide from fuel combustion and volatile organic gases from evaporated petroleum products react in the presence of sunshine.

In the absence of cooling effects provided by trees, higher temperatures contribute to ozone (O_3) formation. Additionally, short-term increases in ozone concentrations are statistically associated with increased tree mortality for 95 large US cities (Bell and others, 2004).

However, it should be noted that while trees do a great deal to absorb air pollutants (especially ozone and particulate matter); they also negatively contribute to air pollution. Trees emit various biogenic volatile organic compounds (BVOCs), such as isoprene's and monoterpenes, which also contribute to ozone formation. i-Tree *Streets* analysis accounts for these BVOC emissions in the air quality net benefit.

Deposition and Interception

Each year, 1.9 tons of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), small particulate matter (PM_{10}), and ozone (O_3) are intercepted or absorbed by community trees in Pacific Grove, for a value of $39,085 (Table 8). As a population, Monterey cypress (*Cupressus macrocarpa*) is the greatest contributor to pollutant deposition and interception, accounting for 38% of these benefits.

Avoided Pollutants

The energy savings provided by trees have the additional indirect benefit of reducing air pollutant emissions (NO_2, PM_{10}, SO_2, and VOCs) that result from energy production. Altogether, 1,042 pounds of pollutants, valued at $8,825, are avoided annually through the shading effects of Pacific Grove's community trees.

BVOC Emissions

Biogenic volatile organic compound (BVOC) emissions from trees, which negatively affect air quality, must also be considered along with the benefits. Approximately 7.9 tons of BVOCs are emitted annually from community trees, offsetting the total air quality impact by -$114,312. Of the prevalent species, the heaviest emitters by population are coast live oak (*Quercus agrifolia*) emitting 40% of BVOCs, and blue gum (*Eucalyptus globulus*, 30%). Red flowering gum (*Eucalyptus ficifolia*) is also a significant contributor BVOC emissions (2,244 lbs) and it is only 2% of the population. Monterey cypress (*Cupressus macrocarpa*, 607 lbs) and Monterey pine (*Pinus radiata*, 598 lbs) both contribute to the overall loss in air quality benefits, but at a lower rate. These trees make up 46% of the population and although they are high emitters of BVOCs, they also intercept air pollutants (NO2, PM10, SO2, and VOCs) valued in excess of their BVOC emissions for net positive air quality benefit of $4.08/tree (*Pinus radiata*) and $8.21/tree (*Cupressus macrocarpa).*

Net Air Quality Improvement

The net value of air pollutants removed by community trees in Pacific Grove is -$66,401 annually. This is mainly due to the high populations of trees that emit high level of BVOCs. The overall average net air quality impact per tree is -$8.98. As trees that emit high levels of BVOCs mature and decline, future tree planting should emphasize planting large-canopied trees with large leaf surface areas that are typically not high emitters of BVOCs. Monterey cypress (*Cupressus* macrocarpa, $8.21) and Monterey pine (*Pinus radiata* $4.08) currently produce the greatest per tree net air quality benefits (Figure 11).

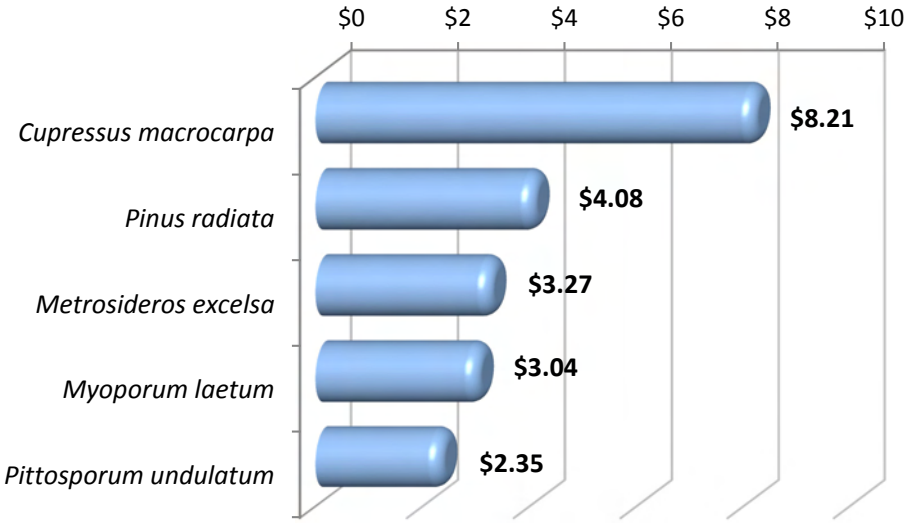

Figure 11. Top 5 Species for Per-Tree Annual Air Quality Benefits

Table 8. Summary of Annual Air Quality Benefits from Pacific Grove's Community Tree Resource

Species	Deposition O_3 (lb.)	Deposition NO_2 (lb.)	Deposition PM_{10} (lb.)	Deposition SO_2 (lb.)	Total Deposition ($)	Avoided NO_2 (lb.)	Avoided PM_{10} (lb.)	Avoided VOC (lb.)	Avoided SO_2 (lb.)	Total Avoided ($)	BVOC Emissions (lb.)	BVOC Emissions ($)	Total (lb.)	Total ($)	% of Pop	Avg. $/tree
Quercus agrifolia	265	116.54	180	22.71	**6,141**	152.84	38.33	19.72	80.28	**2,465**	- 6,369	**- 45,987**	- 5,494	**- 37,381**	29.62	**- 17.07**
Pinus radiata	420	184.90	262	36.05	**9,454**	153.59	38.31	19.73	80.08	**2,472**	- 598	**- 4,314**	597	**7,611**	25.24	**4.08**
Cupressus macrocarpa	665	292.79	394	57.10	**14,724**	139.00	35.07	18.02	73.64	**2,247**	- 607	**- 4,386**	1,067	**12,586**	20.73	**8.21**
Eucalyptus globulus	179	78.62	103	15.33	**3,924**	26.96	6.73	3.46	14.06	**434**	- 4,765	**- 34,405**	- 4,338	**- 30,047**	2.85	**- 142.40**
Metrosideros excelsa	17	7.62	12	1.49	**398**	5.01	1.32	0.67	2.82	**83**	0	**0**	48	**481**	1.99	**3.27**
Eucalyptus ficifolia	51	22.46	31	4.38	**1,144**	16.19	3.92	2.03	8.09	**257**	- 2,244	**- 16,205**	- 2,105	**- 14,803**	1.79	**- 112.15**
Myoporum laetum	11	4.86	7	0.95	**251**	4.01	1.02	0.52	2.14	**65**	0	**0**	32	**316**	1.41	**3.04**
Pinus pinea	4	1.94	3	0.38	**107**	5.42	1.36	0.70	2.84	**87**	- 18	**- 131**	2	**63**	1.31	**0.65**
Prunus cerasifera	2	0.63	1	0.12	**36**	1.08	0.28	0.14	0.58	**18**	0	**0**	5	**53**	1.11	**0.65**
Pittosporum undulatum	7	3.04	4	0.59	**153**	1.41	0.38	0.19	0.81	**23**	0	**0**	17	**177**	1.01	**2.35**
Other Trees	125	52.81	75	10.38	**2,753**	41.86	10.48	5.39	21.95	**675**	- 1,230	**- 8,884**	- 888	**- 5,456**	12.94	**- 5.70**
All Trees	**1,745**	**766.20**	**1,072**	**149.46**	**$39,085**	**547.37**	**137.18**	**70.58**	**287.29**	**$8,825**	**- 15,833**	**-$114,312**	**- 11,057**	**-$66,401**	**100%**	**-$ 8.98**

Stormwater Runoff Reductions

Rainfall interception by trees reduces the amount of stormwater that enters collection and treatment facilities during large storm events. Trees intercept rainfall in their canopy, acting as mini-reservoirs, controlling runoff at the source. Healthy urban trees reduce the amount of runoff and pollutant loading in receiving waters in three primary ways:

- Leaves and branch surfaces intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.
- Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow.
- Tree canopies reduce soil erosion and surface flows by diminishing the impact of raindrops on bare soil.

Community trees in Pacific Grove intercept more than 14.2 million gallons of stormwater annually for an average of 1,926 gallons per tree (Table 9).The total value of this benefit to the City is $56,949, an average of $7.70 per tree. The City recognizes that trees and vegetation help mitigate stormwater. As of 2014, residents building or replacing between 2,500 to 15,000 square feet or more of impervious surface, must prepare a landscape plan for the property. This regulation shows that City Planners understand that landscaping can help mitigate stormwater runoff.

Overall, among prevalent species, blue gum (*Eucalyptus globulus)* currently provides the greatest per tree benefit of $17.56, followed by red flowering gum (*Eucalyptus ficifolia*) $13.03 (Figure 12). The population of Monterey cypress (*Cupressus macrocarpa*) provides the largest portion of stormwater benefit at 29%, but this value is aligned with their prevalence in the population as they represent 21% of all trees.

As trees grow, their benefits tend to increase, but some species will ultimately realize more substantial benefits than others will. Some tree species currently demonstrating lower benefits, including purple leaf plum (*Prunus cerasifera*, $0.68/tree), are small canopy broadleaf deciduous trees. As such, their benefits will not increase much over time. However, medium-stature evergreen trees such as Victorian box (*Pittosporum undulatum*, $1.88/tree), which have a high percentage of immature trees in the current population should see increased benefits as these younger individuals mature.

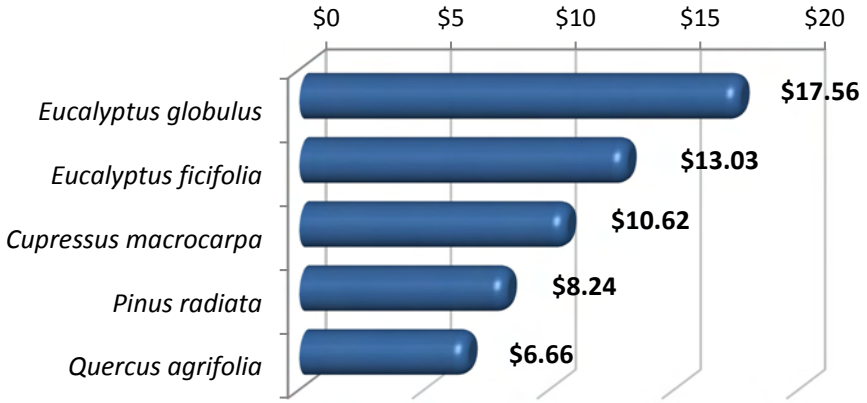

Figure 12. Top 5 Species for Annual Stormwater Benefits

Table 9. Summary of Annual Stormwater Runoff Reduction Benefits from Pacific Grove's Community Tree Resource

Species	Total Rainfall Interception (Gal)	Total ($)	% of Pop	% of Total $	Avg. $/tree
Quercus agrifolia	3,647,735	**14,591**	29.62	25.62	**6.66**
Pinus radiata	3,842,658	**15,371**	25.24	26.99	**8.24**
Cupressus macrocarpa	4,069,542	**16,278**	20.73	28.58	**10.62**
Eucalyptus globulus	926,116	**3,704**	2.85	6.50	**17.56**
Metrosideros excelsa	151,162	**605**	1.99	1.06	**4.11**
Eucalyptus ficifolia	429,940	**1,720**	1.79	3.02	**13.03**
Myoporum laetum	94,919	**380**	1.41	0.67	**3.65**
Pinus pinea	109,441	**438**	1.31	0.77	**4.51**
Prunus cerasifera	13,939	**56**	1.11	0.10	**0.68**
Pittosporum undulatum	35,261	**141**	1.01	0.25	**1.88**
All Trees	**916,508**	**3,666**	**12.94**	**6.44**	**3.83**

Aesthetic, Property Value, and Socioeconomic Benefits

Trees provide beauty in the urban landscape, privacy to homeowners, improved human health, a sense of comfort and place, and habitat for urban wildlife. Research shows that trees promote better business by stimulating more frequent and extended shopping and a willingness to pay more for goods and parking (Wolf, 1999). Some of these benefits are captured as a percentage of the value of the property on which a tree stands. To determine the value of these less tangible benefits, i-Tree *Streets* uses research that compares differences in sales prices of homes to estimate the contribution associated with trees. Differences in housing prices in relation to the presence (or lack) of a street tree help define the aesthetic value of street trees in the urban environment.

The calculation of annual aesthetic and other benefits corresponds with a tree's annual increase in leaf area. When a tree is actively growing, leaf area may increase dramatically. Once a tree is mature, there may be little or no net increase in leaf area from one year to the next; thus, there is little or no incremental annual aesthetic benefit for that year, although the cumulative benefit over the course of the entire life of the tree may be large. Since this report represents a one-year sample snapshot of the inventoried tree population, **aesthetic benefits reflect the increase in leaf area for each species population over the course of a single year.**

The total annual benefit from Pacific Grove's community trees associated with property value increases and other less tangible benefits is nearly $1.1 million, an average of $141 per tree (Table 10). Overall, among prevalent species, red flowering gum (*Eucalyptus ficifolia*, $240) and blue gum (*Eucalyptus globulus*, $238) provide the greatest per-tree aesthetic value annually.

Figure 13. Urban trees promote retail shopping by stimulating more frequent visits and a willingness to pay more for goods and services (Wolf 1999).

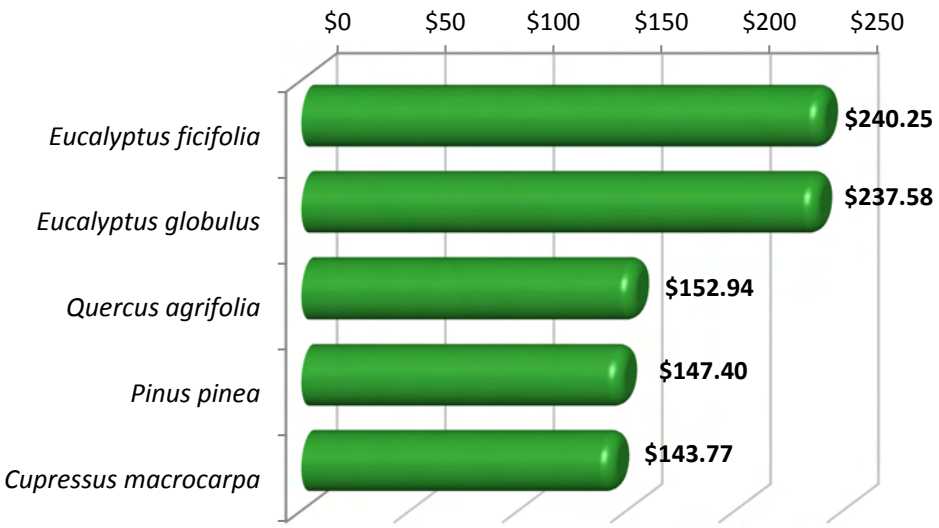

Figure 14. Top 5 Species for Annual Aesthetic Benefits

Table 10. Summary of Annual Aesthetic, Property Value, and Socioeconomic Benefits from Pacific Grove's Community Tree Resource

Species	Total ($)	% of Pop	% of Total $	Avg. $/tree
Quercus agrifolia	**334,928**	29.62	32.04	**152.94**
Pinus radiata	**267,644**	25.24	25.60	**143.43**
Cupressus macrocarpa	**220,404**	20.73	21.08	**143.77**
Eucalyptus globulus	**50,128**	2.85	4.80	**237.58**
Metrosideros excelsa	**8,029**	1.99	0.77	**54.62**
Eucalyptus ficifolia	**31,713**	1.79	3.03	**240.25**
Myoporum laetum	**8,936**	1.41	0.85	**85.92**
Pinus pinea	**14,298**	1.31	1.37	**147.40**
Prunus cerasifera	**3,548**	1.11	0.34	**43.27**
Pittosporum undulatum	**4,018**	1.01	0.38	**53.58**
Other Trees	**101,709**	12.94	9.73	**106.28**
All Trees	**$1,045,356**	**100%**	**100%**	**$141.38**

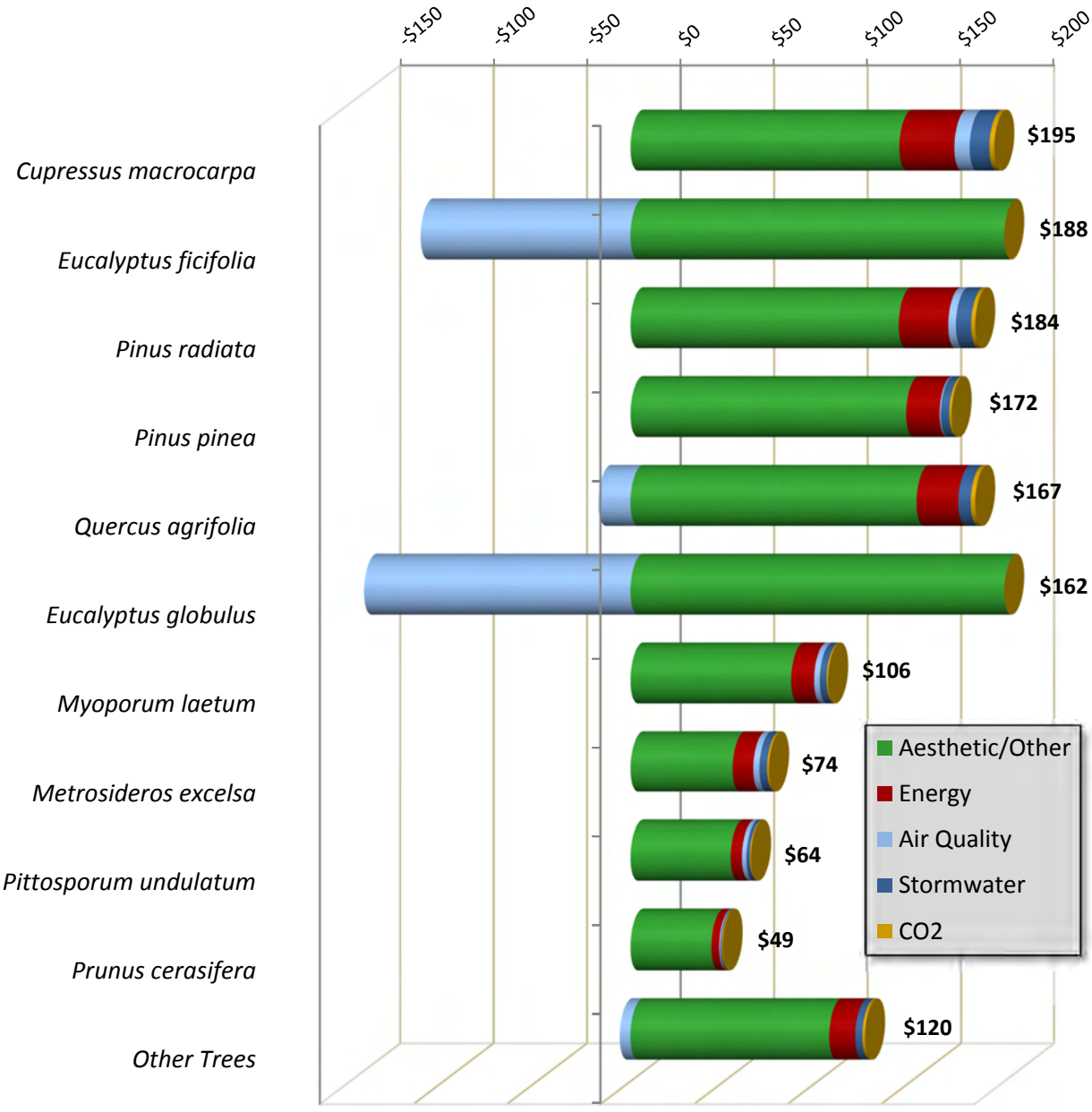

Figure 15. Summary of Annual Per-Tree Benefits from Predominant Species (representing>1%)

Table 11. Summary of Annual per Tree Benefits from Species Representing > 1%

Species	Energy	CO2	Air Quality	Stormwater	Aesthetic/Other	Total
Quercus agrifolia	22.38	2.41	- 17.07	6.66	152.94	**167.32**
Pinus radiata	26.48	2.17	4.08	8.24	143.43	**184.39**
Cupressus macrocarpa	29.44	2.63	8.21	10.62	143.77	**194.67**
Eucalyptus globulus	41.49	7.90	- 142.40	17.56	237.58	**162.11**
Metrosideros excelsa	11.04	0.99	3.27	4.11	54.62	**74.03**
Eucalyptus ficifolia	39.06	7.31	- 112.15	13.03	240.25	**187.50**
Myoporum laetum	12.26	0.77	3.04	3.65	85.92	**105.64**
Pinus pinea	17.90	1.23	0.65	4.51	147.40	**171.70**
Prunus cerasifera	4.17	0.45	0.65	0.68	43.27	**49.22**
Pittosporum undulatum	6.03	0.55	2.35	1.88	53.58	**64.40**
Other Trees	13.90	1.37	- 5.70	3.83	106.28	**119.67**
All Trees	**$23.83**	**$2.39**	**-$8.98**	**$7.70**	**$141.38**	**$166.32**

Net Benefits and Benefit versus Investment Ratio (BIR)

Pacific Grove receives substantial benefits from their community urban forest; however, the City must also consider their investments in maintaining this resource. Applying a *benefit-investment ratio* (BIR) is a useful way to evaluate the public investment in a community tree resource. A BIR is an indicator used to summarize the overall value compared to the investments of a given resource. Specifically, in this analysis, BIR is the ratio of the total value of benefits provided by all the City's community trees compared to the cost (investment) associated with their management.

Pacific Grove's community urban forest has beneficial effects on the environment. Approximately $184,447 of the total annual benefits (over $1.2 million) quantified in this study are environmental services (Table 12). Energy savings, valued at $176,195, account for the greatest environmental benefits, followed by stormwater benefits ($56,949), and carbon reduction ($17,704). Annual increases to property value, socioeconomic, and other aesthetic benefits are substantial, accounting $1.1 million of all benefits.

The total estimated benefits provided by Pacific Grove's city-maintained community urban forest is nearly $1.2 million, a value of $166.32 per tree and $79.32 per capita. These benefits are realized on an annual basis. It is important to acknowledge that this is not a full accounting of the benefits provided by this resource, as some benefits are intangible and/or difficult to quantify, such as impacts on psychological health, crime, and violence. Empirical evidence of these benefits does exist (Wolf, 2007; Kaplan, 1989; Ulrich, 1986), but there is limited knowledge about the physical processes at work and the complex nature of interactions make quantification imprecise. Tree growth and mortality rates are highly variable. A true and full accounting of benefits and investments must consider variability among sites (e.g., tree species, growing conditions, maintenance practices) throughout the City, as well as variability in tree growth. In other words, **trees are worth far more than what one can ever quantify!**

When the City's annual estimated expenditure (or investment) of $299,571 in this resource is considered, the net annual benefit (benefits minus investment) to the City is $930,232. The average net benefit for an individual community tree in Pacific Grove is $125.81 and the per capita net benefit is $60.00. **Pacific Grove is currently receiving $4.11 in benefits for every $1 invested in community trees.**

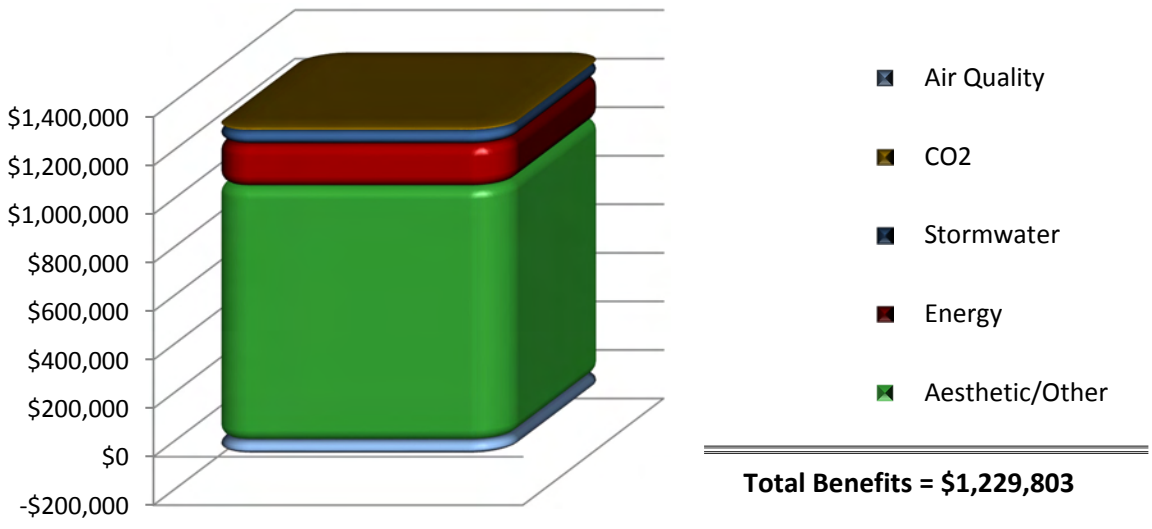

Figure 16. Total Annual Benefits from Community Trees in Pacific Grove

Total Annual Benefits: $1.2 million

Average Annual per Tree Benefit: $166.32

Annual Value of Benefits per Capita: $79.32

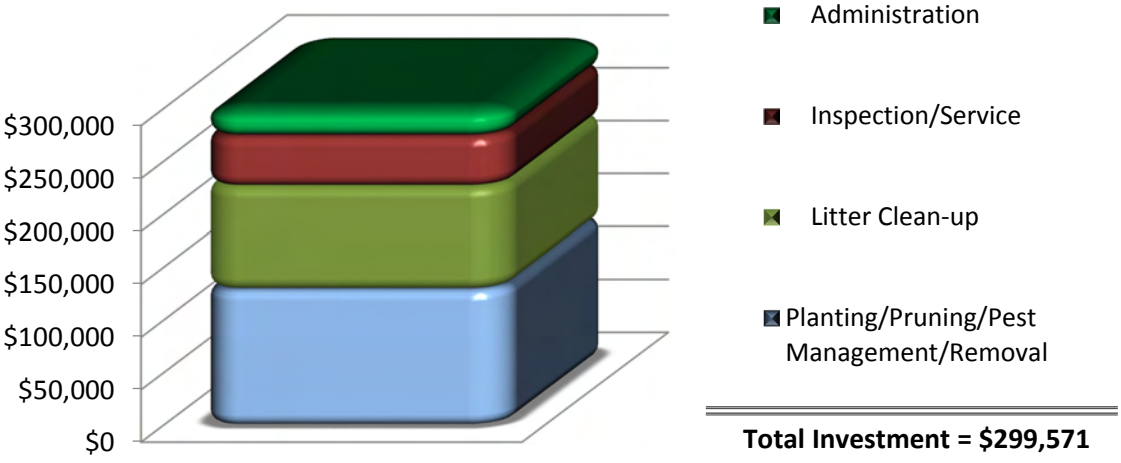

Figure 17. Total Annual Investment to Publicly Maintain Trees in Pacific Grove

Total Annual Investment: $299,571

Average Annual per Tree Investment: $40.52

Annual Investment per Capita: $19.32

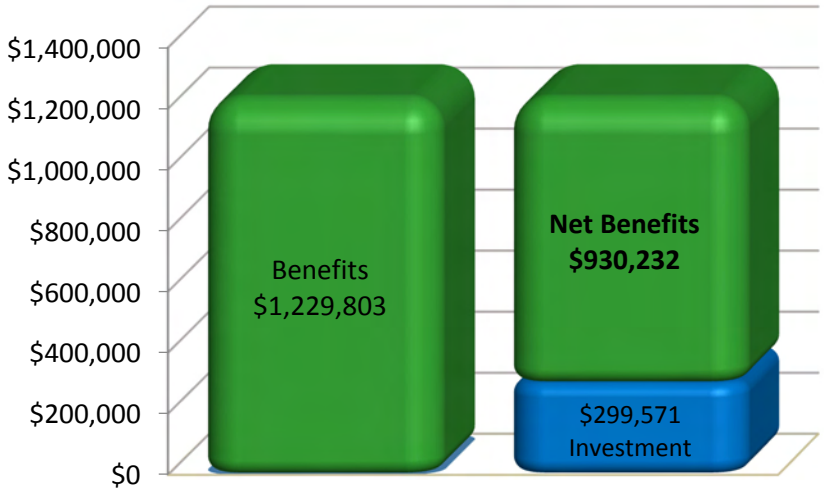

Figure 18. Benefit versus Investment Ratio

Annual Net Benefit of Publicly Maintained Trees in Pacific Grove: $930,232

For EVERY $1 invested in publicly maintained trees, Pacific Grove receives: $4.11 in benefits

Table 12. Annual Benefit versus Investment Summary for all Community Trees

Benefits	Total ($)	$/tree	$/capita
Energy	176,195	23.83	11.36
CO2	17,704	2.39	1.14
Air Quality	- 66,401	- 8.98	- 4.28
Stormwater	56,949	7.70	3.67
Aesthetic/Other	1,045,356	141.38	67.42
Total Benefits	**$1,229,803**	**$166.32**	**$79.32**

Investment			
Planting/Pruning/Pest Management/Removal	129,651	17.53	8.36
Administration	25,000	3.38	1.61
Inspection/Service	48,000	6.49	3.10
Litter Clean-up	96,920	13.11	6.25
Total Investment	**$299,571**	**$40.52**	**$19.32**

Net Benefit	$930,232	$125.81	$60.00

Benefit Investment Ratio	$4.11

Conclusion

This analysis describes the current structural characteristics of Pacific Grove's community urban forest resource, using established tree sampling, numerical modeling, and statistical methods to provide a general accounting of the benefits. The analysis provides a "snapshot" of this resource at its current population, structure, and condition. Rather than examining each individual tree, as an inventory does, the resource analysis examines trends and performance measures over the entire urban forest and each of the major species populations within.

Community trees are providing quantifiable impacts on air quality, reduction in atmospheric CO_2, stormwater runoff, and aesthetic benefits. The City's 7,394 trees are providing over $1.2 million in annual gross benefits. That is an average of $166.32 per tree and $79.32 per capita.

The community urban forest in Pacific Grove has a nearly ideal age distribution of young to established trees in fair to good condition. The resource has a healthy diversity with more than 136 different species. The City can increase the benefits from this resource by using all available planting sites to increase the stocking level (currently 92.2%) as well as replacing mature trees that are in decline and recommended for removal (8%).The City should continue to focus resources on preserving existing and mature trees to promote health, strong structure, tree longevity, and manage risk. Structural and training pruning for young trees will maximize the value of this resource, reduce long-term maintenance costs, and ensure that as trees mature they provide the greatest possible benefits over time. Davey Resource Group recommends the following:

- Increase species diversity by insuring that new tree plantings include a variety of suitable species and don't unduly increase reliance on prevalent species.
- Increase stocking level by using all available planting sites to improve diversity and increase benefits. Install large-stature species wherever space allows.
- Provide structural pruning for young trees and a regular pruning cycle for all trees.
- Protect existing trees and manage risk with regular inspection to identify and mitigate structural and age-related defects.
- Continue to maintain and update the inventory database, including tracking tree growth and condition during regular pruning cycles.
- For greater air quality benefits, new planting should include trees that emit less biogenetic organic compounds (BVOCs).

Urban forest managers can better anticipate future trends with an understanding of the current status of the City's tree population. Managers can also anticipate challenges and devise plans to increase the current level of benefits. Performance data from the analysis can be used to make determinations regarding species selection, distribution, and maintenance policies. Documenting current structure is necessary for establishing goals and performance objectives and can serve as a benchmark for measuring future success. Information from the urban forest resource analysis can be referenced in development of an urban forest management or master plan. An urban forest master plan is a critical tool for successful urban forest management, inspiring commitment and providing vision for communication with key decision-makers both inside and outside the organization.

Pacific Grove's community trees are of vital importance to the environmental, social, and economic well-being of the community. The City has demonstrated that public trees are a valued community

resource, a vital component of the urban infrastructure, and an important part of the City's history and identity. The inventory data can be used to plan a proactive and forward-looking approach to the future care of community trees. Updates should continue to be incorporated into the inventory a regular maintenance is performed, including updating the DBH and condition of existing trees. Current and complete inventory data will help staff to more efficiently track maintenance activities and tree health and will provide a strong basis for making informed management decisions. A continued commitment to planting, maintaining, and preserving these trees, will support the health and welfare of the City and the surrounding region.

Figure 19. Trees are an important part of the city's history and identity.

Appendix A: Methodology

In 2015, Certified Arborists collected an inventory of the community trees in Pacific Grove, including details about each tree's species, size, and condition. The inventory data was formatted for use in i-Tree's public tree population assessment tool, i-Tree *Streets*, a STRATUM Analysis Tool (Streets v 5.1.5; i-Tree v 6.0.9). i-Tree *Streets* assesses tree population structure and the function of those trees, such as their role in building energy use, air pollution removal, stormwater interception, carbon dioxide removal, and property value increases. To analyze the economic benefits of Pacific Grove's community trees, i-Tree *Streets* calculates the dollar value of annual resource functionality. This analysis combines the results of the City's tree inventory with benefit modeling data to produce information regarding resource structure, function, and value for use in determining management recommendations. i-Tree *Streets* regionalizes the calculations of its output by incorporating detailed reference City project information for 17 climate zones across the United States (Pacific Grove is located in the Northern California Coast Climate Zone).

An annual resource unit was determined on a per tree basis for each of the modeled benefits. Resource units are measured as MWh of electricity saved per tree; MBtu of natural gas conserved per tree; pounds of atmospheric CO_2 reduced per tree; pounds of NO_2,SO_2, O_3, PM_{10}, and VOCs reduced per tree; cubic feet of stormwater runoff reduced per tree; and square feet of leaf area added per tree to increase property values.

Price values assigned to each resource unit (tree) were generated based on economic indicators of society's willingness to pay for the environmental benefits trees provide. The City provided the estimated investment costs for contracted and in-house tree services, pest management, administration, and inspections.

Estimates of benefits are initial approximations as some benefits are difficult to quantify (e.g. impacts on psychological health, crime, and violence). In addition, limited knowledge about the physical processes at work and their interactions makes estimates imprecise (e.g., fate of air pollutants trapped by trees and then washed to the ground by rainfall). Therefore, this method of quantification provides first-order approximations based on current research. It is intended to be a general accounting of the benefits produced by urban trees.

Table 13. Pacific Grove Benefit Prices Used In This Analysis

Benefits	Price	Unit	Source
Electricity	0.15	$/Kwh	Pacific Gas and Electric
Natural Gas	1.32	$/Therm	Pacific Gas and Electric
CO_2	0.0075	$/lb.	Streets default – Northern California Coast
PM_{10}	11.79	$/lb.	Streets default – Northern California Coast
NO_2	10.31	$/lb.	Streets default – Northern California Coast
SO_2	3.72	$/lb.	Streets default – Northern California Coast
VOC	7.22	$/lb.	Streets default – Northern California Coast
Stormwater Interception	0.004	$/gallon	Streets default – Northern California Coast
Median Home Value	731,000	$	City of Pacific Grove

i-Tree *Streets* default values (Table 13) from the Northern California Coast Climate Zone were used for all benefit prices except for the median home value, and electrical and natural gas rates. Using these rates, the magnitude of the benefits provided by the inventoried tree resource was calculated using i-Tree *Streets***.** Median home value, electrical and gas rates, and program investment costs were supplied by the City of Pacific Grove.

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Appendix C: Tables

Table 14. Complete Population Summary of Tree Species in Pacific Grove's Community Urban Forest

Species	DBH Class (in)									Total	%of Pop
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42		
Broadleaf Deciduous Large (BDL)											
Platanus hybrida	0	12	12	10	1	0	0	0	0	35	0.47
Ulmus americana	0	0	2	9	11	6	1	4	1	34	0.46
Ulmus parvifolia	2	0	4	2	1	0	1	0	0	10	0.14
Fraxinus uhdei	0	1	1	0	0	0	0	0	0	2	0.03
Juglans nigra	0	0	0	0	1	0	0	0	1	2	0.03
Ulmus pumila	0	0	0	0	1	0	0	0	0	1	0.01
Platanus racemosa	0	0	1	0	0	0	0	0	0	1	0.01
Liriodendron tulipifera	0	0	0	0	0	1	0	0	0	1	0.01
Quercus species	0	1	0	0	0	0	0	0	0	1	0.01
BDL Total	**2**	**14**	**20**	**21**	**15**	**7**	**2**	**4**	**2**	**87**	**1.18%**
Broadleaf Deciduous Medium (BDM)											
Liquidambar styraciflua	9	14	15	5	0	0	0	0	0	43	0.58
Robinia x ambigua	10	1	1	0	0	0	0	0	0	12	0.16
Betula pendula	0	7	3	2	0	0	0	0	0	12	0.16
Pyrus calleryana	2	8	1	1	0	0	0	0	0	12	0.16
Salix species	0	0	5	3	1	1	0	0	0	10	0.14
Acacia spp.	0	0	5	0	0	0	0	0	0	5	0.07
Alnus rhombifolia	0	0	3	1	0	0	0	0	0	4	0.05
Ulmus spp.	0	0	3	0	1	0	0	0	0	4	0.05
Betula nigra	0	4	0	0	0	0	0	0	0	4	0.05
Nyssa sylvatica	0	3	0	0	0	0	0	0	0	3	0.04
Ginkgo biloba	3	0	0	0	0	0	0	0	0	3	0.04
Acer rubrum	0	2	1	0	0	0	0	0	0	3	0.04
Robinia pseudoacacia	0	0	0	2	0	0	0	0	0	2	0.03
Morus alba	0	0	1	1	0	0	0	0	0	2	0.03
Pterocarya stenoptera	2	0	0	0	0	0	0	0	0	2	0.03
Albizia julibrissin	0	0	0	1	0	0	0	0	0	1	0.01
Salix babylonica	0	0	0	0	0	0	0	1	0	1	0.01
Prunus subhirtella	0	1	0	0	0	0	0	0	0	1	0.01
Salix matsudana	0	0	1	0	0	0	0	0	0	1	0.01
Aesculus species	0	1	0	0	0	0	0	0	0	1	0.01

Species	DBH Class (in)									Total	%of Pop
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42		
BDM Total	**26**	**41**	**42**	**16**	**2**	**1**	**0**	**1**	**0**	**129**	**1.74%**
Broadleaf Deciduous Small (BDS)											
Prunus cerasifera	31	34	17	0	0	0	0	0	0	82	1.11
Crataegus phaenopyrum	11	0	0	0	0	0	0	0	0	11	0.15
Prunus X blireana	2	6	2	0	0	0	0	0	0	10	0.14
Malus species	5	3	0	0	0	0	0	0	0	8	0.11
Prunus ilicifolia lyonii	0	3	2	0	0	0	0	0	0	5	0.07
Acer palmatum	3	1	1	0	0	0	0	0	0	5	0.07
Prunus serrulata	3	1	1	0	0	0	0	0	0	5	0.07
Aesculus californica	0	0	0	1	1	0	0	0	0	2	0.03
Pyrus communis	2	0	0	0	0	0	0	0	0	2	0.03
Cercis canadensis	2	0	0	0	0	0	0	0	0	2	0.03
Ribes sanguineum	1	0	0	0	0	0	0	0	0	1	0.01
Ficus carica	0	1	0	0	0	0	0	0	0	1	0.01
Prunus ilicifolia	0	0	1	0	0	0	0	0	0	1	0.01
Prunus dulcis	0	1	0	0	0	0	0	0	0	1	0.01
Prunus domestica	0	0	1	0	0	0	0	0	0	1	0.01
Prunus species	0	0	1	0	0	0	0	0	0	1	0.01
Cotinus coggygria	1	0	0	0	0	0	0	0	0	1	0.01
BDS Total	**61**	**50**	**26**	**1**	**1**	**0**	**0**	**0**	**0**	**139**	**1.88%**
Broadleaf Evergreen Large (BEL)											
Quercus agrifolia	37	168	925	681	237	82	34	15	11	2190	29.62
Eucalyptus globulus	0	5	48	25	20	16	13	21	63	211	2.85
Eucalyptus sideroxylon	0	0	3	1	15	8	5	1	0	33	0.45
Podocarpus gracilior	6	3	0	0	0	0	0	0	0	9	0.12
Umbellularia californica	0	0	1	2	2	1	0	0	0	6	0.08
Eucalyptus species	0	0	2	1	1	0	0	0	0	4	0.05
Eucalyptus polyanthemos	0	0	0	0	1	2	0	0	0	3	0.04
Eucalyptus citriodora	0	0	1	0	0	0	0	1	0	2	0.03
Grevillea robusta	0	0	0	2	0	0	0	0	0	2	0.03
Eucalyptus viminalis	0	0	0	0	1	0	0	0	0	1	0.01
BEL Total	**43**	**176**	**980**	**712**	**277**	**109**	**52**	**38**	**74**	**2461**	**33.28%**
Broadleaf Evergreen Medium (BEM)											
Metrosideros excelsa	6	27	45	39	20	10	0	0	0	147	1.99
Eucalyptus ficifolia	0	1	11	25	46	21	19	6	3	132	1.79
Pittosporum undulatum	6	25	37	6	1	0	0	0	0	75	1.01

Species	DBH Class (in)									Total	%of Pop
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42		
Maytenus boaria	11	11	17	8	0	0	0	0	0	47	0.64
Olea europaea	14	12	4	0	0	0	0	0	0	30	0.41
Acacia longifolia	0	3	20	3	0	1	0	0	0	27	0.37
Ilex aquifolium	0	12	8	4	1	0	0	0	0	25	0.34
Acacia melanoxylon	1	1	10	5	2	1	2	0	0	22	0.30
Magnolia grandiflora	3	8	5	0	0	0	1	0	0	17	0.23
Syzygium paniculatum	0	3	5	5	0	0	0	0	0	13	0.18
Melaleuca quinquenervia	0	1	6	0	0	0	0	0	0	7	0.09
Cinnamomum camphora	0	6	0	0	0	0	0	0	0	6	0.08
Eucalyptus nicholii	0	0	0	0	2	0	3	1	0	6	0.08
Lyonothamnus floribundus asplen	0	1	4	0	0	0	0	0	0	5	0.07
Schinus molle	0	1	3	0	0	0	0	0	0	4	0.05
Laurus nobilis	1	2	0	0	1	0	0	0	0	4	0.05
Ligustrum lucidum	0	2	0	0	0	0	0	0	0	2	0.03
Acacia baileyana	0	1	1	0	0	0	0	0	0	2	0.03
Persea americana	0	0	1	0	0	0	0	0	0	1	0.01
Eucalyptus cinerea	0	0	0	1	0	0	0	0	0	1	0.01
Geijera parviflora	0	0	1	0	0	0	0	0	0	1	0.01
BEM Total	**42**	**117**	**178**	**96**	**73**	**33**	**25**	**7**	**3**	**574**	**7.76%**

Broadleaf Evergreen Small (BES)											
Myoporum laetum	1	22	67	13	1	0	0	0	0	104	1.41
Callistemon citrinus	4	4	16	5	0	0	0	0	0	29	0.39
Heteromeles arbutifolia	1	7	18	0	1	0	0	0	0	27	0.37
Arbutus x marina	2	6	12	2	0	0	0	0	0	22	0.30
Pittosporum crassifolium	0	4	7	3	0	0	0	0	0	14	0.19
Arbutus unedo	3	6	3	1	0	0	0	0	0	13	0.18
Ilex spp.	0	2	5	1	1	0	0	0	0	9	0.12
Acacia verticillata	0	5	2	0	0	0	0	0	0	7	0.09
Callistemon viminalis	0	4	2	1	0	0	0	0	0	7	0.09
Leptospermum laevigata	0	0	4	2	1	0	0	0	0	7	0.09
Melaleuca linariifolia	0	0	2	2	1	0	0	0	0	5	0.07
Leptospermum scoparium	1	1	2	0	0	0	0	0	0	4	0.05
Pyrus kawakamii	0	2	2	0	0	0	0	0	0	4	0.05
Tristaniopsis laurina	4	0	0	0	0	0	0	0	0	4	0.05
Eucalyptus conferruminata	0	0	1	1	0	1	0	0	0	3	0.04
Schinus terebinthifolius	0	0	0	2	1	0	0	0	0	3	0.04
Pyracantha species	0	0	2	0	0	0	0	0	0	2	0.03
Dodonaea viscosa	0	0	2	0	0	0	0	0	0	2	0.03
Citrus limon	0	1	1	0	0	0	0	0	0	2	0.03

Species	DBH Class (in)									Total	%of Pop
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42		
Xylosma congestum	0	1	0	0	0	0	0	0	0	1	0.01
Garrya elliptica	0	0	1	0	0	0	0	0	0	1	0.01
Fremontodendron californicum	0	1	0	0	0	0	0	0	0	1	0.01
Citrus sinensis	0	1	0	0	0	0	0	0	0	1	0.01
Ligustrum japonicum	0	0	1	0	0	0	0	0	0	1	0.01
Eriobotrya japonica	1	0	0	0	0	0	0	0	0	1	0.01
Rhus lancea	0	0	1	0	0	0	0	0	0	1	0.01
Agonis flexuosa	1	0	0	0	0	0	0	0	0	1	0.01
BES Total	**18**	**67**	**151**	**33**	**6**	**1**	**0**	**0**	**0**	**276**	**3.73%**
Conifer Evergreen Large (CEL)											
Pinus radiata	159	112	373	393	342	245	127	74	41	1,866	25.24
Cupressus macrocarpa	60	114	291	280	216	155	112	96	209	1,533	20.73
Pinus pinea	7	15	33	33	8	1	0	0	0	97	1.31
Sequoia sempervirens	11	25	21	2	3	0	2	2	2	68	0.92
Pinus torreyana	1	1	6	5	5	1	3	0	0	22	0.30
Pinus canariensis	5	1	1	0	0	0	0	0	0	7	0.09
Cedrus atlantica	0	0	1	5	1	0	0	0	0	7	0.09
Cedrus deodara	2	0	1	1	2	0	0	0	0	6	0.08
Araucaria heterophylla	1	2	0	1	0	0	1	0	0	5	0.07
Pseudotsuga menziesii	0	0	0	0	2	1	0	0	0	3	0.04
Cupressus spp.	0	1	0	2	0	0	0	0	0	3	0.04
Pinus thunbergiana	0	2	1	0	0	0	0	0	0	3	0.04
Calocedrus decurrens	0	0	1	0	1	0	0	0	0	2	0.03
Sequoiadendron giganteum	0	0	0	0	1	1	0	0	0	2	0.03
Casuarina cunninghamiana	0	0	0	0	1	0	0	0	0	1	0.01
Abies pinsapo	0	0	0	1	0	0	0	0	0	1	0.01
CEL Total	**246**	**273**	**729**	**723**	**582**	**404**	**245**	**172**	**252**	**3,626**	**49.04%**
Conifer Evergreen Medium (CEM)											
Pinus species	2	3	2	2	0	0	0	0	0	9	0.12
Ceanothus spp.	0	0	4	0	0	0	0	0	0	4	0.05
Myrica californica	0	2	0	0	0	0	0	0	0	2	0.03
Myrtus communis	0	0	2	0	0	0	0	0	0	2	0.03
Pinus sylvestris	0	0	1	0	0	0	0	0	0	1	0.01
Cupressocyparis x leylandii	0	0	0	0	1	0	0	0	0	1	0.01
Cunninghamia lanceolata	0	1	0	0	0	0	0	0	0	1	0.01
CEM Total	**2**	**6**	**9**	**2**	**1**	**0**	**0**	**0**	**0**	**20**	**0.27%**

Species	DBH Class (in)									Total	%of Pop
	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	> 42		
Conifer Evergreen Small (CES)											
Taxus baccata	2	1	2	1	1	0	0	0	0	7	0.09
CES Total	**2**	**1**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**7**	**0.09%**
Palm Evergreen Large (PEL)											
Phoenix canariensis	0	0	3	2	1	8	13	12	2	41	0.55
PEL Total	**0**	**0**	**3**	**2**	**1**	**8**	**13**	**12**	**2**	**41**	**0.55%**
Palm Evergreen Small (PES)											
Washingtonia robusta	0	0	4	2	6	0	0	0	0	12	0.16
Cordyline australis	1	4	5	1	0	0	0	0	0	11	0.15
Trachycarpus fortunei	0	0	4	0	0	0	0	0	0	4	0.05
Arecastrum romanzoffianum	2	1	0	0	0	0	0	0	0	3	0.04
Washingtonia filifera	0	0	1	1	0	1	0	0	0	3	0.04
Yucca elephantipes	0	0	0	1	0	0	0	0	0	1	0.01
PES Total	**3**	**5**	**14**	**5**	**6**	**1**	**0**	**0**	**0**	**34**	**0.46%**
Grand Total	**445**	**750**	**2,154**	**1,612**	**965**	**564**	**337**	**234**	**333**	**7,394**	**100%**

Table 15. Relative Performance of All Species

Species	Dead or Dying	Poor	Fair	Good	N/A	Very Good	RPI	# of Trees	% of Pop
Quercus agrifolia	0.78	10.64	49.95	38.36	0.18	0.09	**1.00**	2,190	29.62
Pinus radiata	11.36	10.50	40.89	32.48	0.86	3.91	**0.91**	1,866	25.24
Cupressus macrocarpa	3.65	5.81	40.51	47.49	1.37	1.17	**1.03**	1,533	20.73
Eucalyptus globulus	0.47	1.90	36.49	61.14	0.00	0.00	**1.12**	211	2.85
Metrosideros excelsa	0.00	1.36	39.46	57.14	0.68	1.36	**1.12**	147	1.99
Eucalyptus ficifolia	0.00	5.30	62.88	31.82	0.00	0.00	**1.00**	132	1.79
Myoporum laetum	5.77	21.15	38.46	33.65	0.96	0.00	**0.90**	104	1.41
Pinus pinea	3.09	4.12	31.96	60.82	0.00	0.00	**1.10**	97	1.31
Prunus cerasifera	0.00	12.20	32.93	54.88	0.00	0.00	**1.07**	82	1.11
Pittosporum undulatum	0.00	2.67	46.67	49.33	0.00	1.33	**1.09**	75	1.01
Sequoia sempervirens	0.00	5.88	45.59	47.06	0.00	1.47	**1.07**	68	0.92
Maytenus boaria	6.38	4.26	31.91	55.32	2.13	0.00	**1.03**	47	0.64
Liquidambar styraciflua	0.00	4.65	37.21	58.14	0.00	0.00	**1.11**	43	0.58
Phoenix canariensis	0.00	0.00	17.07	80.49	0.00	2.44	**1.22**	41	0.55
Platanus hybrida	2.86	2.86	45.71	48.57	0.00	0.00	**1.06**	35	0.47
Ulmus americana	0.00	14.71	47.06	38.24	0.00	0.00	**0.99**	34	0.46
Eucalyptus sideroxylon	0.00	12.12	75.76	12.12	0.00	0.00	**0.90**	33	0.45
Olea europaea	0.00	0.00	43.33	56.67	0.00	0.00	**1.12**	30	0.41
Callistemon citrinus	0.00	0.00	31.03	68.97	0.00	0.00	**1.16**	29	0.39
Acacia longifolia	3.70	18.52	62.96	14.81	0.00	0.00	**0.86**	27	0.37
Heteromeles arbutifolia	0.00	3.70	40.74	55.56	0.00	0.00	**1.10**	27	0.37
Ilex aquifolium	0.00	4.00	44.00	52.00	0.00	0.00	**1.09**	25	0.34
Acacia melanoxylon	4.55	9.09	59.09	27.27	0.00	0.00	**0.94**	22	0.30
Arbutus x marina	0.00	9.09	22.73	68.18	0.00	0.00	**1.13**	22	0.30
Pinus torreyana	0.00	0.00	9.09	81.82	0.00	9.09	**1.25**	22	0.30
Magnolia grandiflora	0.00	5.88	76.47	11.76	0.00	5.88	**0.95**	17	0.23
Pittosporum crassifolium	0.00	14.29	50.00	35.71	0.00	0.00	**0.99**	14	0.19
Syzygium paniculatum	0.00	0.00	92.31	7.69	0.00	0.00	**0.93**	13	0.18
Arbutus unedo	0.00	0.00	15.38	84.62	0.00	0.00	**1.22**	13	0.18
Pyrus calleryana	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	12	0.16
Betula pendula	0.00	8.33	41.67	50.00	0.00	0.00	**1.06**	12	0.16
Robinia x ambigua	0.00	16.67	25.00	58.33	0.00	0.00	**1.06**	12	0.16
Washingtonia robusta	0.00	0.00	0.00	66.67	0.00	33.33	**1.31**	12	0.16
Crataegus phaenopyrum	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	11	0.15
Cordyline australis	0.00	0.00	36.36	63.64	0.00	0.00	**1.14**	11	0.15
Ulmus parvifolia	0.00	30.00	50.00	20.00	0.00	0.00	**0.87**	10	0.14
Salix species	0.00	10.00	70.00	10.00	10.00	0.00	**0.81**	10	0.14
Prunus X blireana	0.00	10.00	50.00	40.00	0.00	0.00	**1.02**	10	0.14
Pinus species	0.00	22.22	44.44	33.33	0.00	0.00	**0.95**	9	0.12
Podocarpus gracilior	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	9	0.12

Species	Dead or Dying	Poor	Fair	Good	N/A	Very Good	RPI	# of Trees	% of Pop
Ilex spp.	0.00	0.00	33.33	66.67	0.00	0.00	**1.16**	9	0.12
Malus species	0.00	25.00	37.50	37.50	0.00	0.00	**0.95**	8	0.11
Pinus canariensis	0.00	0.00	0.00	85.71	0.00	14.29	**1.29**	7	0.09
Taxus baccata	0.00	0.00	28.57	71.43	0.00	0.00	**1.17**	7	0.09
Callistemon viminalis	0.00	0.00	14.29	85.71	0.00	0.00	**1.23**	7	0.09
Leptospermum laevigata	0.00	0.00	71.43	28.57	0.00	0.00	**1.01**	7	0.09
Melaleuca quinquenervia	0.00	0.00	14.29	85.71	0.00	0.00	**1.23**	7	0.09
Acacia verticillata	0.00	28.57	42.86	28.57	0.00	0.00	**0.90**	7	0.09
Cedrus atlantica	0.00	0.00	0.00	85.71	0.00	14.29	**1.29**	7	0.09
Eucalyptus nicholii	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	6	0.08
Umbellularia californica	0.00	0.00	33.33	66.67	0.00	0.00	**1.16**	6	0.08
Cedrus deodara	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	6	0.08
Cinnamomum camphora	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	6	0.08
Melaleuca linariifolia	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	5	0.07
Acer palmatum	0.00	40.00	60.00	0.00	0.00	0.00	**0.75**	5	0.07
Prunus ilicifolia lyonii	0.00	0.00	40.00	60.00	0.00	0.00	**1.13**	5	0.07
Acacia spp.	0.00	0.00	40.00	40.00	20.00	0.00	**0.87**	5	0.07
Araucaria heterophylla	0.00	0.00	40.00	60.00	0.00	0.00	**1.13**	5	0.07
Prunus serrulata	0.00	0.00	20.00	80.00	0.00	0.00	**1.21**	5	0.07
Lyonothamnus floribundus asplen	0.00	20.00	40.00	40.00	0.00	0.00	**0.98**	5	0.07
Tristaniopsis laurina	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	4	0.05
Schinus molle	0.00	50.00	25.00	25.00	0.00	0.00	**0.81**	4	0.05
Ulmus spp.	0.00	0.00	25.00	50.00	25.00	0.00	**0.87**	4	0.05
Leptospermum scoparium	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	4	0.05
Laurus nobilis	0.00	25.00	0.00	75.00	0.00	0.00	**1.09**	4	0.05
Pyrus kawakamii	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	4	0.05
Trachycarpus fortunei	0.00	0.00	25.00	75.00	0.00	0.00	**1.19**	4	0.05
Alnus rhombifolia	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	4	0.05
Eucalyptus species	25.00	0.00	75.00	0.00	0.00	0.00	**0.72**	4	0.05
Ceanothus spp.	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	4	0.05
Betula nigra	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	4	0.05
Washingtonia filifera	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	3	0.04
Acer rubrum	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	3	0.04
Nyssa sylvatica	0.00	0.00	33.33	66.67	0.00	0.00	**1.16**	3	0.04
Cupressus spp.	0.00	0.00	33.33	66.67	0.00	0.00	**1.16**	3	0.04
Eucalyptus polyanthemos	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	3	0.04
Pinus thunbergiana	0.00	0.00	66.67	33.33	0.00	0.00	**1.03**	3	0.04
Schinus terebinthifolius	0.00	0.00	66.67	33.33	0.00	0.00	**1.03**	3	0.04
Arecastrum romanzoffianum	0.00	0.00	33.33	66.67	0.00	0.00	**1.16**	3	0.04
Pseudotsuga menziesii	0.00	33.33	33.33	33.33	0.00	0.00	**0.90**	3	0.04
Eucalyptus conferruminata	0.00	0.00	66.67	33.33	0.00	0.00	**1.03**	3	0.04

Species	Dead or Dying	Poor	Fair	Good	N/A	Very Good	RPI	# of Trees	% of Pop
Ginkgo biloba	0.00	0.00	33.33	66.67	0.00	0.00	**1.16**	3	0.04
Ligustrum lucidum	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	2	0.03
Pterocarya stenoptera	0.00	50.00	50.00	0.00	0.00	0.00	**0.72**	2	0.03
Grevillea robusta	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	2	0.03
Morus alba	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	2	0.03
Juglans nigra	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	2	0.03
Fraxinus uhdei	0.00	50.00	50.00	0.00	0.00	0.00	**0.72**	2	0.03
Cercis canadensis	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	2	0.03
Sequoiadendron giganteum	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	2	0.03
Pyrus communis	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	2	0.03
Acacia baileyana	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	2	0.03
Citrus limon	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	2	0.03
Eucalyptus citriodora	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	2	0.03
Calocedrus decurrens	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	2	0.03
Myrtus communis	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	2	0.03
Robinia pseudoacacia	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	2	0.03
Dodonaea viscosa	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	2	0.03
Pyracantha species	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	2	0.03
Myrica californica	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	2	0.03
Aesculus californica	0.00	0.00	50.00	50.00	0.00	0.00	**1.09**	2	0.03
Abies pinsapo	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Citrus sinensis	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Ficus carica	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Liriodendron tulipifera	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Prunus species	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Cupressocyparis x leylandii	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Quercus species	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Rhus lancea	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Prunus domestica	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Prunus subhirtella	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Salix matsudana	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Agonis flexuosa	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Ligustrum japonicum	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Pinus sylvestris	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Cunninghamia lanceolata	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Persea americana	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Aesculus species	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Cotinus coggygria	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Eriobotrya japonica	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Casuarina cunninghamiana	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Prunus dulcis	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01

Species	Dead or Dying	Poor	Fair	Good	N/A	Very Good	RPI	# of Trees	% of Pop
Yucca elephantipes	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Geijera parviflora	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Eucalyptus cinerea	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Eucalyptus viminalis	0.00	100.00	0.00	0.00	0.00	0.00	**0.53**	1	0.01
Xylosma congestum	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Garrya elliptica	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Ribes sanguineum	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Salix babylonica	100.00	0.00	0.00	0.00	0.00	0.00	**0.15**	1	0.01
Prunus ilicifolia	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Albizia julibrissin	0.00	100.00	0.00	0.00	0.00	0.00	**0.53**	1	0.01
Ulmus pumila	0.00	0.00	100.00	0.00	0.00	0.00	**0.90**	1	0.01
Platanus racemosa	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
Fremontodendron californicum	0.00	0.00	0.00	100.00	0.00	0.00	**1.28**	1	0.01
All Trees	**4.11**	**8.47**	**43.63**	**41.71**	**0.64**	**1.45**	**1.00**	**7,394**	**100%**